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OF THE STATE OF PENNSYLVANIA,

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DEVOTED TO

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AND THE RECORD OF PATENT INVENTIONS.

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**JANUARY, 1861.**

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## CIVIL ENGINEERING.

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For the Journal of the Franklin Institute.

*Abstract of a Report by Croizette Desnoyers upon that part of the Bourbonnais Railroad between St. Germain-des-Fossès and Roanne, a distance of* 41 *miles.* Translated by J. Bennett.

It would appear from the opening of this report, that the difficulty of procuring ready information upon railroad works is felt in France as well as in the United States. It is only by visiting the works themselves, or through the special courtesy of those who superintend them, that such information can be had; it was partly to fill this gap that the author made the report of which the following is an abstract.

This road, uniting the valleys of the Allier and Loire, presents in its central portion a varied profile, calling for the construction of a great number of works, no one in particular having a marked importance above other structures of late years; for its tunnels are not so long as those of Blaisy or of Credo, nor are its viaducts comparable in height to those of Gartempe or of Chaumont; but there is a variety in the works: their dimensions, though more common in practice, are still important, and in this regard a description of them may be useful. Moreover, there are valuable facts and figures to be cited, and accidents to be mentioned, which, though unattended with serious consequences, may indicate in certain cases the precautions to be taken, and the dangers to be shunned.

With the brief statement that the works were conceded by the state to the Orleans Company, by an agreement of June, 1855; that there were two summits to be surmounted, one between the Allier and Bèbre, with a maximum grade of 42 ft. the mile, the other between the Bèbre and Loire, with a maximum of 47·5 ft.; that the minimum radius of curvature was 1640 ft.; we pass over the changes in the organization of the road, the details of its alignment, the reasons that controlled some important features in its location, and proceed with an account of its construction.

*Division in Sections.*—The first section is from St. Germain to Palisse, 10·8 miles.

The second from Palisse to Pacaudiere, 16·2 miles.

The third from Pacaudiere to Roanne, 14 miles.

This division corresponds with the character of the ground; the extreme sections lying mostly in the tertiary earths, the central being entirely of a granite formation.

*Earthworks.*—The difficulties in earthworks were also of different characters. At St. Germain the soil is very clayey, and there were many landslides, and many consolidating works; further on, the road crossed sandy clay, which, without causing massive slides, would form ravines with extreme facility, against which many precautions were taken. Beyond the Bèbre, the granitic or porphyretic soil is sometimes composed of very hard rocks, and sometimes of a more or less profound decomposed rock, known in the country by the name of *gore;* moreover, in the hardest parts there were faults filled with clay, upon which the blocks slid, causing serious accidents.

*Limits of Height.*—The limits of height at centre line adopted for earthwork, were from 65 to 82 ft. for excavation, and 82 to 92 ft. for embankment. These limits may evidently vary for particular cases; yet for excavating, the above named should not be surpassed, especially in steep slopes, as in that case the slope on the highest side may reach 100 ft. in vertical height; now, whatever the hardness of the rock may be, it is seldom so compact and homogeneous as to be held at that height, even upon a gentle slope, without risk; and, on the other hand, if the usual slope is adopted, the volume would be too great and the expense inadmissible. For embankments, on the contrary, such good results have been obtained from the use of decomposed granite in securing compactness and stability, that with this material, we should venture without fear upon a height of 130 ft., were it not that a viaduct would generally prove to be a more economical structure.

*Profile of Embankment.*—The profiles for great embankments had the usual slope of 3 base to 2 in height, and were strengthened with berms 6·5 ft. wide, at vertical distances of 19½ ft. All the earth of the lower part from the dumpings of the carts was taken up in barrows, and was spread in level layers up to 39 ft. below the top. At the commencement, these precautions were taken with all the banks; but afterwards, such was the confidence in the above named good re-

sults, the berms and rehandling were dispensed with in earths of good quality.

The increase in bulk of embankments was very considerable. Independently of the voids left by hard rocks in the banks, the gores, which were so compact as to require the pick and blasting for their excavation, were turned into coarse sand, with an increased volume; the increase in these earths was frequently ⅐th.

*Profile of Excavation.*—In hard rock the slope was 1 in 4. In all other earth excavations, there was a berm 3 ft. wide at the foot of the slopes, which varied from 1 to 1·5 base to 1 in height. In unsolid earth there was a slope of 45°, with berms at intervals of 10 ft.; but if these berms are convenient for the flow of water, and tend to lessen defacements of the slope, they cannot well be maintained without lining; and it would be best to dispense with them by making an increased slope.

*Table of Quantities of Work and Costs.*

| Contents. | Sec. 1 | Sec. 2. | Sec. 3. | Total. |
|---|---|---|---|---|
| | cub. met. | cub. met. | cub. met. | cub. met. |
| Contents of earth works, . | 675,430 | 2,226,000 | 540,000 | 3,411,430 |
| Amount per lineal metre, . | 39 | 86 | 23 | 52 |
| | francs. | francs. | francs | francs. |
| Cost including accessory works, | 1,150,000 | 5,000.000 | 1,034,000 | 7,184,000 |
| Cost per lineal metre, . | 66 | 192 | 46 | 109 |
| | f. | f. | f. | f. |
| Mean cost per cubic metre, . | 1·70 | 2·24 | 2 03 | 2·10 |

Note.—1 cubic metre = 1·308 cubic yards. 1 franc per cubic metre = 15·29 cents per cubic yard.

The mean prices per cubic metre of the different sections do not vary so much as might have been expected in passing from the tertiary to granitic earths; this is due to the fact, that the proportion of rock to be excavated on section 2, was less than anticipated; to the less distance of haul, which at a mean was 400 metres, while it was 600 upon section 1; and to the fact, that there was but 6 per cent. of accessory works on section 2, while there was 21 per cent. on section 1.

*Accessory works. Embankment over the Girauds Pond.*—The road crosses many ponds, and as there had been among the first worked much expensive mucking, an attempt was made in this case to dispense with the greater portion of it. For this purpose, the muck was only taken away from the foot of each slope, and the solid earth being laid bare, two strong banks, well pugged, were raised upon it, provision being made for the flow of the central water through rubble drains. It was thought that the mud thus retained would only experience compression under the bank, and, except an unavoidable settling, that it could be constructed without accident. But in reality the mud was forced in front of the dumpings between the two ramps; so that the embankment attained the solid earth, and all the mud driven before

it had to be taken away, and the process did not succeed, though the filling was only 33 ft. high.

From this experiment and the effects in crossing other ponds, under the pressure of a bank but slightly elevated, it follows that the soft mud is displaced, and to avoid slides and disjunction it is necessary that a previous mucking be made, unless the banks are of an excellent quality; but with dry sand or rocky debris, the mud may be suffered to be forced on either side.

*The Pouzoux Embankment.*—The commencement of the most elevated of the embankments (92 ft. at the centre, and 108 ft. on lower slope), caused much trouble.

The earths composed of *gore* intermixed with clay, though enclosed by a bank at foot of slope, slid upon each other, so that the embankment had scarcely reached a third of its height when serious disorders were encountered. They arose solely from the filtering of spring waters issuing from the rock beneath; it sufficed to put in the middle of the bank a rubble drain 6 ft. wide, with some lateral branches, and to line the base of the lower slope with a strong enrockment let into the natural soil. Generally where slides may be expected or water is to be imprisoned, a simple pipe drainage will answer.

*St. Germain Embankment.*—On the St. Germain side, layers of earth from 6 to 10 ft. thick, have slid upon the core of the bank, and though replaced by good earth, well rammed and secured by checks, these new strips were again detached. There were two methods used for arresting them: 1st, by forming a sand berm at the foot of the slope; 2d, by making at intervals cuts 3 ft. deep across the slopes, and then filling them with stones. The latter method is efficacious in preserving the bank, and preventing the propagation of defacings, and is recommended; it might also be used in banks of a shifting nature. In many cases, the sand berm will answer every purpose.

Of course the above does not apply to banks of pure clay; for it should be deposited one side, and its place renewed with good borrowed earth.

*Defacement of Surface.*—Even when the banks are so solid as to cause no fear of slides, there may still be defacements and ravines; the latter occur frequently in granitic earths, because the decomposed rocks form a very movable sand which does not become compact with time or pressure, and because from the abrupt slopes of these earths, the waters pour down with great force and velocity. To prevent these defacements, care was taken, 1st, either by cross trenches or by linings, to keep the attacks of the water from off the foot of the slopes; 2d, by making small ramps, ·4 to ·5 ft. high, along the edge of the banks, in front of which the slopes and counter slopes conduct the water to the grass descents established at intervals of 160 ft. upon the slopes; wherever this precaution was neglected, and the berms were not maintained, ravines occurred. The existence of the berms causes some difficulty in the care of the road-bed, but they are only needed until the seed-plots and plantings upon the slopes have succeeded. In the worst earths, seed-plots of furze or broom were used

with success; grain and oats were sown, and they served to protect the broom, which, in the year following, grew thick upon the slope, and formed a good defence. In all the lower parts of great embankments, acacias were set out in a quintuncial form, 20 ins. apart.

*Slides and Defacements of Slopes.*—There were many slides; all that was done was to take off the extra stuff, to regulate the surface, to increase at need the inclination of the slopes, to insure the flow of water, and in most cases to line the sides; but in no case were the voids refilled, for experience proved that they would not stand fast.

*Protection of the Slopes.*—The favorite method of protecting the slopes was in the increase of water descent and in the leading of surface water to them by drains. Common drainage pipes are the most economical, though more expensive when laid in slopes than on a level surface, but sometimes in excavations the water is too abundant for the discharge of simple pipes; and often in decomposed granitic earths the pipes are easily choked up; in that case rubble drains are to be made; and when the earths are of a very bad quality, recourse is had to brick kennels.

The descents for drainage water are made on sods or in curved pipes; masonry descents are much more costly, and should be reserved for points with large supplies of water.

Water gutters should always be made upon the crests of excavation; sometimes these trenches receive a great supply of water, which, filtering through the section which separates it from the slope, bursts through the dyke causing more serious slides than the surface waste, which they were made to guard against. If a large volume of water comes to the crest, the ditch must be made further back or lined with masonry; in common cases a simple trench will answer.

Drainage pipes have been placed parallel to the slope at a depth of $2\frac{1}{2}$ feet below the bottom of the crest gutter, to catch the water which filters through it, and they have answered a good purpose.

*Lining.*—In excavation the seeding seldom succeeds without vegetable earth; there were two kinds of earth lining used: the first 6 inches, the second 12 inches thick; the first is ineffectual in clayey earth, being easily detached and succeeding only on very inclined slopes; the second worked better, though much given to sliding upon slopes of 45°, and is often nearly as expensive as an enrockment.

In sandy clay, subject to being ravined by the action of storms, soddings were effectual; they formed horizontal belts at intervals of 6 feet, with sods placed normal to the slope and one foot thick; vertical belts at intervals of $16\frac{1}{2}$ feet, and within this frame-work sodding 4 inches thick was laid flatwise; drainage tubes conducted the water in the grass descents placed at every 33 feet; thus the slope is secured, the lining is held firmly by the footing belts, and it is much less costly than if composed entirely of sods placed normal. The expense does not exceed one franc per square metre, drainage, water descents, and incidentals included.

Whenever the above linings were insufficient, an enrockment was used; rubble ditches were made $6\frac{1}{5}$ miles, $\frac{1}{3}$ the length of the total excavation.

## Viaducts.

There are five viaducts constructed upon this branch; we record the differences between them, and compare them with their cost.

*Palisse Viaduct over the Bèbre.*—This viaduct is formed of 8 full centre arches with a span of 46 feet; its length is 545·8 feet and its height is 110 feet above the bed of river. The piers are 11·8 feet thick at the springing line, and are strengthened with counterforts terminated with battlements. The viaduct is crowned by a plinth supporting a cast iron railing over the arches and embattled parapets above the piers and abutments. The foundations are upon a hard granitic rock, and the surface is leveled with a layer of beton, which in pier 2 was $3\frac{3}{4}$ feet deep.

Its proximity to the city and great prominence called for some elegance in construction; still the piers and arches are simple and the upper part alone is ornamented. The material is handsome and cut with care, though the cut stone is restricted to the parts usually deemed essential.

*The Feige Viaduct.*—This viaduct is of a different construction from the above, being simple as possible, entirely formed of rubble in 8-inch courses, with no cut stone except the upper course of the plinth; at each angle chisel drafts follow the edges throughout the length.

The piers are strengthened with counterforts, whose effects give spirit to the structure, which, being entirely of a reddish brown porphyry with homogeneous faces, has a good appearance and a character of solidity, there being nothing to call off the attention from the principal lines, which stand out very distinctly.

Neither in this or the Palisse viaduct are there any belts or offsets at the springing line, the arches being an uninterrupted continuation of the piers, thus increasing the apparent height as seen from below and having a good effect.

The following dimensions are taken from the plans:

Details of Length.

| | | |
|---|---|---|
| 7 arches, 45·92 ft., . | 321·44 | feet. |
| 6 piers, 11·8, . | 70·80 | " |
| 2 abutments, 33 45, . | 66·90 | " |
| Total length, | 459 14 | " |

Details of Height.

| | | |
|---|---|---|
| Pedestal of Pier 4, | 17 | feet. |
| Shaft, . | 55·10 | " |
| Rise of arch, . | 22·96 | " |
| Thickness of key, . | 2·62 | " |
| " between key and plinth, . | 1·64 | " |
| Plinth, . | 1·97 | " |
| Height above foundation, | 101 29 | " |

*Monteiant Viaduct.*

Details of Length.

| | | |
|---|---|---|
| 8 arches of 39·36 feet, | 314·9 | feet. |
| 7 piers of 9 18 feet, . | 64 3 | " |
| 2 abutments of 24·27 feet, | 48·5 | " |
| Total length, | 427·7 | " |

Details of Height.

| | | |
|---|---|---|
| Pedestal of piers, . | 15·42 | feet. |
| Shaft " | 44·30 | " |
| Rise of arches, . | 19·70 | " |
| Thickness of key, | 2 50 | " |
| Between key and plinth, | 1·97 | " |
| Plinth, . | 1·57 | " |
| Total height, | 85·36 | " |

Cut stone is used for the belts and angles, but with small dimensions; the counterforts are suppressed and the work is reduced to the most simple form. The faces are of red granite rustic, upon which the Chevroches limestone belting-courses are drafted with good effect. The foundations are upon a hard gore from 6 to 10 feet below the natural surface. The parapet is composed of a series of cast iron bays with openings, separated by cut stone blocks at intervals of 9·84 feet. These bays, like those of the Feige viaduct, are like most of the handrails on the bridges of Paris, only that the size of the empty spaces were increased, for, owing to their height and the short distance from which they could be seen, they would otherwise have appeared as solid. The parapet weighs 80·4 lbs. per foot; that of the Bèbre viaduct has a less simple form and weighs 107 lbs. per foot.

*Nérard Viaduct.*

| Details of Length. | | |
|---|---|---|
| 5 arches of 55·76 feet, | 278·80 | feet. |
| 4 piers of 12·13 feet, | 48·52 | " |
| 2 abutments of 36·40 feet, | 72·80 | " |
| Total length, | 400·12 | " |

| Details of Height. | | |
|---|---|---|
| Pedestal of piers, | 16·40 | feet. |
| Shaft " | 36·08 | " |
| Rise of arches, | 27·88 | " |
| Thickness of key, | 2·79 | " |
| Between key and plinth, | 2·13 | " |
| Plinth, | 1·31 | " |
| Total height, | 86·59 | " |

The increased span is due to the mossy bottom of the Nérard valley, the difficulties of foundation causing a reduction in the number of piers. These foundations, which went down about 13 feet to the hard gore, called for much excavation, which had to be supported with timber on account of the many slides. The mode of construction is the same as the Monteiant, only that the dimensions of the cut stone were reduced and brought to a minimum; the counterforts might have been suppressed, as far as concerns the height, but the viaduct is built on a curve, and for ease of construction right cylindrical arches were formed resting upon piers of a trapezoidal section; the projection of the counterforts saved the straightening of the heads and avoided the breaks usually apparent in the intradoses with polygonal angles. The plinth and parapet are laid in a curve; the latter consisting of four courses of rustic masonry capped by a curved cut stone.

In all the preceding works care was taken to continue throughout the height, the batter of the heads, and counterforts, without a change at the springing line, as is frequently done, occasioning a kind of horizontal breach in the plan of the heads of the work.

*The Sapin Viaduct.*

| Details of Length. | | |
|---|---|---|
| 11 arches of 32·8 feet, | 360·8 | feet. |
| 2 abutment piers of 13.12 ft., | 26·24 | " |
| 8 piers of 7·55 feet, | 60·40 | " |
| 2 abutments of 32·8 feet, | 65·60 | " |
| Total length, | 513·01 | " |

| Details of Height. | | |
|---|---|---|
| Pedestal of piers, | 21·65 | feet. |
| Shaft " | 44·77 | " |
| Rise of arches, | 16·40 | " |
| Thickness of key, | 2·95 | " |
| Between key and plinth, | 1·64 | " |
| Plinth, | 1·97 | " |
| Total height, | 89·38 | " |

This viaduct differs from the others in that the arches are smaller and the thickness of the piers is not constant. The arches are separated in three groups by two abutting piers, there being five in the centre and three on each side. This arrangement gives it more of a monumental character than the preceding, while the smallness of the arches increases the apparent height. It is built of grey granite rubble, with chain courses, angles, and belts of cut limestone. The parapet is wholly of cut stone. The piers and abutments rest upon hard gore, and there were difficulties in foundations both from their depth and from bad weather.

*Abutments.*—In all the above-named viaducts the abutments have a rectangular horizontal section hollowed in the centre with a vertical pit of a circular or elliptic section. This arrangement guards completely against the accidents which usually follow from the use of wing walls in such works. Abutments from 50 to 66 feet high require an enormous thickness of wing walls, and the included prism of earth in storms exerts a pressure resisted with difficulty by these walls. This form of abutment was used twelve years ago in the viaducts of Indre and the Manse, but is not generally adopted in France, though there have been serious accidents in some magnificent works by defect of this precaution.

The quarter cones of abutments have inclinations varying from 45° to $1\frac{1}{2}$ base for 1 in height. Those of 45° give rise to landslides, even with enrockment at the base, and it is best to have an inclination of $1\frac{1}{2}$ or $1\frac{1}{4}$ at the least. When the extreme piers are partially covered by these quarter cones, it is well to support them by counterforts.

| Prices. | Viaducts. | | | | | Average |
|---|---|---|---|---|---|---|
| | Bèbre. | Monteiant. | Nérard | Feige. | Sapins | |
| | francs. | francs. | francs. | francs. | francs. | francs. |
| Cost per linear metre, . | 4159 | 2548 | 2977 | 2917 | 3165 | 3195 |
| " per square metre in elevation, | 165 | 125 | 133 | 119 | 137 | 137 |
| " per cubic metre of masonry, | 45 | 34 | 34 | 31 | 36 | 36 |

Note. 1 franc per linear metre = 18·28 cents per linear yard.
1 " square do. = 16·72 " square "
1 " cubic do. = 15·29 " cubic "

It is seen that the Bèbre viaduct is the most costly, the Sapin the next, and that the three others do not differ widely.

The Monteiant, Nérard, and Sapin viaducts are nearly of the same height, and in good condition for comparison, and it appears that their respective prices per linear metre, have nearly the same proportion as the price per superficial metre; the conclusion, then, derived from these three adopted types, is that the most economical is the one which has arches of 39 ft. span; the next in order is that with spans of 55 feet, and the most costly is that with 33 ft. span. Too small arches evidently have this disadvantage, that the surface of the lateral faces of piers increases with the number of the arches much more than they

are diminished in surfaces of elevation; but, on the other hand, when certain limits of span are exceeded, we require more costly centerings and materials, and increased thicknesses; thus the span of from 39 to 46 ft. appears to be the most preferable in the conditions of our viaducts, and they are most generally adopted by engineers for similar heights.

In comparing the superficial metre in elevation, the price is seen to range from 119 to 165 francs, or reducing the last limit to a comparable rate of elementary cost, from 119 to 150 francs; so that between the adoption of the different types, the expense may vary $\frac{1}{5}$th, a consideration prompting the use of the most economical dispositions, though there may be local exigencies which may justify a departure from them.

The use of very hard granite rubble justifies the differences in the cost of these viaducts and those recently constructed upon other lines at a cost of 100 francs per superficial metre; with limestone rubble the price would have been reduced on the Feige viaduct from 103 to 104 francs.

It is believed, then, that if a viaduct from 98 to 115 ft. high can be built of limestone for 100 francs per superficial metre, for hard granite the price should be raised from 115 to 120 francs; it is admitted also, that with granite rubble and cut limestone, a simple viaduct, like the Montciant and Nérard, would cost in general from 10 to 15 francs more per metre than a work wholly in rubble, and this difference would lead to a preference for the last type, especially when the effect is as satisfactory.

*Surfaces and Cubes.*—

| | Bèbre. | Montciant. | Nérard. | Feige. | Sapins. | Average. |
|---|---|---|---|---|---|---|
| Ratio of the voids to full spaces (surface in elevation), . . | 1·78 | 1·76 | 1·48 | 1·60 | 1·56 | 1·64 |
| Cube per superficial metre in elevation, . | 3·67 | 3·62 | 3·83 | 3·86 | 3·86 | 3·78 |

The ratio of the void to the full surface is less than in the viaduct of Chaumont (3·12), and a little below that of the Dinan viaduct (2·06), because, all else being equal, the ratio increases with the height of the works; thus, for example, though the Bèbre and Feige viaducts have arches of the same openings and piers of the same thickness, the ratio varies from 1·78 to 1·60, because the latter of these works is less elevated and shorter.

The cubic metres corresponding to the surface metres in elevation, vary but little for the five works, because, though it might seem as if there should be a constant width for works of the same road, and the cubes consequently follow the ratio of the full parts to the voids, yet it must be remembered that the widths are only the same at the summit, that by reason of the battre the mean widths increase with the

height, and the increase is the greater as counterforts are used beyond a certain height, and consequently the increase in width compensates very closely for the reduction resulting from the value of the ratio between the empty and the full.

We give a table showing an apportionment of the cost of the viaducts.

| Cost per Superficial Metre in Elevation. | Viaducts. | | | | | Average. |
|---|---|---|---|---|---|---|
| | Bèbre. | Montciant. | Nérard. | Feige. | Sapins. | |
| | francs. | francs. | francs. | francs. | francs. | francs. |
| Foundations, . . | 14·80 | 5 90 | 13·90 | 8·80 | 13·30 | 11·50 |
| Piers and abutments up to springing line, . | 77 20 | 58·10 | 49 00 | 57·80 | 69·30 | 63 60 |
| From springing line to plinth, . . | 47 40 | 41·30 | 49·00 | 34·90 | 38 80 | 42 10 |
| Plinths and parapets, . | 17 30 | 12 30 | 9 90 | 11 20 | 12 40 | 12 80 |
| Centres, . . . | 8·30 | 7 40 | 11 20 | 6·30 | 3 20 | 7·00 |
| Totals, . . | 165·00 | 125 00 | 133·00 | 119·00 | 137·00 | 137·00 |

For the piers and abutments up to the springing line, the expense increases naturally with the height and number of the piers; for the part between the springing line and plinth, it follows an inverse proportion; with these general inferences we make no further comment upon the table, believing that the previous statements of the character of the work will account sufficiently for the existing differences of cost.

*Pressures.*—

| Portions subjected to Pressure. | Pressure in kil. per sq. centim. for viaducts.* | | | | | Average. |
|---|---|---|---|---|---|---|
| | Bèbre. | Montciant. | Nérard. | Feige. | Sapins | |
| | kil. | kil. | kil. | kil. | kil. | kil. |
| At summit of pier shaft, . | 4·51 | 4 60 | 5·37 | 4·51 | 4·70 | 4·74 |
| At base of pier on pedestal, | 6·92 | 6 18 | 6·58 | 6·32 | 5 20 | 6 24 |
| At base of pedestal, . | 6 07 | 6 96 | 6 12 | 5·24 | 4·80 | 5·84 |
| Upon bottom of foundation, | 6·07 | 6 66 | 5·82 | 4·73 | 3·70 | 5·40 |

* 1 kilogramme per square centimetre = 14·229 lbs. per square inch.

The greatest pressures are in accordance with the different types; they are comprised between 5·20 kil. and 6·96 kil., or 74 lbs. to 99 lbs. per square inch. In the plans, 99·6 lbs. per square inch was taken for the limit. This limit has been exceeded in other similar constructions, and it may be thought that the masonry was too thick; but it must be remembered that the interior of the piers, instead of having blocks with parallel beds, as for the viaduct of Dinan, or the great works of the Limoges line, were simply of rough rubble, quite irregular, which, from their hard granitic character, offered smooth and un-

adhesive surfaces to the mortar; the leveled courses of rubble used were spaced far apart (15 ft. according to plan), and were few in number. An increased thickness thus compensated for these unfavorable conditions. With easily cut stone there may be an advantage in constructing piers with regular courses, but in general as there is no great call for restricting masonry to the minimum thickness, there is a marked economy in building the interior of rough stone. A work with dimensions a little beyond the strict limits of stability, creates confidence, and has a more satisfactory appearance.

The pressures upon the bottom of foundation did not exceed 94·77 lbs. to the square inch; this might have been exceeded upon the Bèbre viaduct, which was upon hard rock; but the other viaducts rested upon decomposed granite, whose hardness varied in the same pit, and it was not deemed prudent to increase the load.

*Scaffolding.*—For the construction of the piers there were two systems of scaffolding; the first, for the viaduct of Bèbre, was composed of a continuous service bridge connected with vertical frames entirely surrounding each pier. The service bridge abutted upon a hill, on the side of which an inclined iron rail track served for raising the materials to the level of the service bridge, while another track upon the bridge conducted them to the axis of the pier for which they were designed; at this point they were taken by a car furnished with a windlass, and moving lengthwise of the pier, so that the stone is readily lodged where it belongs. The frames of the piers, as well as the uprights supporting the service bridge, were at the first set at their full height; but in order that the materials should not be hoisted higher than necessary, the service bridge was secured to the uprights by bolts, thus allowing it to be raised with the advance of the work; the shifting was effected in a few hours, and generally on Sundays, to prevent any interruption of the work. The service bridge of the Bèbre viaduct had siding tracks, which, though generally answering the purpose, were at times obstructed, so that it would be best to lay a double track, as but little increasing the expense.

The second system, that of the Montciant viaduct, was composed of isolated scaffoldings for each pier. The frames were similar to those of the other system, and also had a double moving truck with windlass which raised the stones from the surface of the ground.

The first system is of course more costly in its establishment than the second, but the excess seems to be largely compensated in the diminution of the cost of raising materials and the greater facility it offers for their disposal. A disadvantage in the second system is its liability of obstructing the piers with materials, while the workmen are often kept idle from not finding among them such as they may need. At the Bèbre viaduct the cars were loaded at the ends of the service bridge or upon the sidings, and were not brought to the piers until the moment when they were required, and the stones and mortar were distributed upon either pier without obstructing the masons or causing them to be brought to a stand still. These advantages caused their adoption on the three viaducts last constructed.

This system would not be directly applicable upon a work of great length or where the abutments do not adjoin a hill-side; in that case there should be established a few points with special appliances for hoisting, with a place for the deposit of materials at their summit, from whence they may be distributed by the system already described.

For the Feige viaduct, on account of the small size of material, the service bridge became simply a foot bridge, and the frames around the piers were suppressed, as all the stones were carried and laid by hand. This simplification of scaffolding is one of the great advantages belonging to the use of small stone.

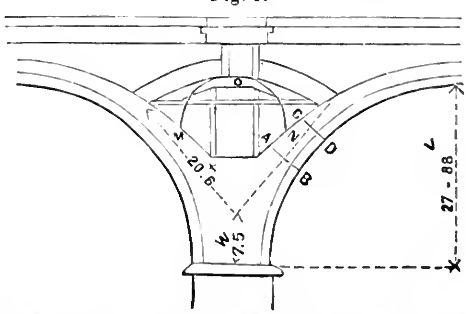
For the construction of the arches, a service bridge was built upon the centres with movable cranes.

*Time used in Building.*—In works of this kind we cannot hasten the construction indefinitely, especially in the rearing of the piers, because the working limits are much restricted. At the Bèbre viaduct from the 30th of April to the 31st of August, or in 120 days, they raised 47 courses of shafts and laid 4 voussoirs upon all the piers, which gives as a mean $2\frac{1}{3}$ days for each course; in pier No. 4, which was behind-hand for some time, 18 courses were laid in $1\frac{1}{2}$ days only; from the finishing of the shaft till the construction of the arches, 40 days were consumed in raising the centres and installing upon them a service bridge with cranes; the arches were afterwards closed in 40 days.

It was supposed that with rubble masonry the piers might be constructed more rapidly, but the workmen say that though rubble is easier to handle, yet it requires more time to lay two courses of angle rubble than a single similar one of cut stone, and in reality, though the work was hastened, as a mean there were but five courses of rubble laid per week, which answers for $2\frac{2}{3}$ days for one course of cut stone; so that the construction entirely in rubble does not seem to present any advantage in respect to rapidity of execution.

*Discharge Arches of the Nérard Viaduct.*—The spandrils of all the viaducts were to have been filled with sand béton, but for the Nérard, as the season was far advanced, and the volume of béton required considerable, it was thought that time might be saved in building discharge

Fig. 1.




arches upon the haunches of the great arches, which might also answer as supports for the service bridge required for the transportation of earth in the winter. The expense was not materially different for

either case. Arches were therefore built according to the figure (1). As the small centre was to be used in another spandril, it was taken down six days after the turning of the discharge arch, while the mortar was yet green, and the great arches themselves but recently constructed. The small arch settled from 3 to 4 inches, and exerted against the flanks of the large arches a pressure so that the archivault was driven inwards from $\frac{6}{10}$ to $\frac{8}{10}$ inch to the right of the small arch, so as to open the joints of the extrados in the directions A B, C D. This accident was due to the incomplete setting of the mortar, but shows also that the small arch was too much surbased, and exerted its thrust at points too distant from the springing line. It would be well then, in such cases, to adopt for the curve of intrados the line M O N. The centerings of the other small arches not having been taken down till after the winter, no settlement occurred, nor was there any appreciable effect upon the haunches of the great arches.

*Accidents in Uncentering.*—In the Nérard and Feige viaducts, owing to bad management in uncentering, the heads were thrust one side at the intrados, though no fissure appeared at the extrados. It is probable that the joints of rubble in contact with the heads, not being well squared, in the different settlings occasioned by irregular uncenterings, exerted an oblique thrust, which forced the heads outwards. The openings of the joints were from $\frac{4}{10}$ to $\frac{6}{10}$ inch. This separation is more easily explained in the Nérard viaduct, whose heads were of cut stone and the remainder of rubble, than in the Feige, whose materials were homogeneous. The joints were repaired, and not the least fissure has since occurred; still, as the arches of the Nérard were large they were secured with iron tie-rods. This accident, though not serious, shows that too much attention cannot be given to taking down of centres, even in full centred arches of small span, and with agents who have successfully executed similar but more difficult works.

*Mortars.*—In the foundations and lower parts of the viaducts, the eminently hydraulic lime of Joze was used. It always gave good results, but its rapid setting caused it to be unfit for great heights with slow processes of hoisting. At first it was replaced by a mean hydraulic lime of Cusset mixed with Auvergne puzzolano and sand; more lately good results were obtained from the use of decomposed porphyry mixed as sand with the mean hydraulic lime. There would have been great economy if they had ventured to use it from the start, but it was thought imprudent until new proofs should corroborate the good results of previous trials; besides setting quickly, it was requisite that its hardness should increase with time, so that the experiments required a long period to be conclusive. The gore or decomposed porphyry gives out a coarse argillaceous sand, and is in reality a kind of puzzolano; an analysis of it was made at the École des Ponts et Chaussées, and its puzzolano qualities were recognised.

An account of the tunnels, sustaining walls, culverts, &c., will be given in the next paper.

(To be Continued.)

## *Observations on the Niagara Bridge.**† By PETER W. BARLOW, Esq., C. E., F. R. S., F. G. S., &c., &c.

As remarked by Mr. Roebling in his very able report to the President and Directors of the Bridge Company in 1855, "one single observation of the passage of a train will convince the most sceptical that the practicability of suspended railway bridges, so much doubted heretofore, has been successfully demonstrated."

On my first arrival there several trains passed over. I placed my eye on a level with the platform, standing off the bridge, but neither wave nor vibration were perceptible to the naked eye. I then stood on the road platform of the bridge, and afterwards on the upper or railway platform, and found no more vibration or undulation (although the road, from the wear of the rails, is out of condition) than is felt in an ordinary suspension bridge from a horse walking over.

If the advocates or admirers of girders or tubes imagine that their mode of construction is free from vibration, they are presuming on a fact of which they will discover the error by standing on a tube or girder while a train passes over it. A train passing even on solid ground over a bad road will cause a sensible vibration in a house at 50 or even 100 yards from a railway.

The idea of a structure free from vibration is therefore imaginary, and inconsistent with the constitution of matter. The question for the practical man alone is the avoidance of such a degree of momentum by vibration or undulation as will produce a strain beyond the limit of the elasticity of the material.

This simple and evident proposition has been generally disregarded by the constructors of suspension bridges, as the platforms have been made, as before observed, without any regard to vertical stiffening; the result of which, in a gale of wind, is a degree of undulation by which strains are produced (judging from the depth of the reported undulations in some cases) equal to five or six times that due to the simple weight on the bridge. No kind of structure is proof against such treatment; and it is more a matter of surprise that they should last so long, than they should frequently fail.

On my second visit to the Niagara Bridge, I observed the deflection, by means of a level, from the passage of an ordinary passenger train, to be ·41 of a foot, which of course includes the amount of wave plus the deflection from the elongation of the cable. The train, which consisted of two American cars, 50 feet long, besides the van and locomotive, I estimated to weigh 80 tons, and the deflection from the actual elongation of the cable to be ·182 of a foot. It is clear, therefore, that the amount of wave, or distortion of the cable from its original figure, does not amount to three inches in a length of 821 feet; a change of figure which, occurring gradually during the progress of a train, does not approach an amount of disturbance sufficient to produce momentum. And it is evident to me that no suspension bridge has

* And on the practicability of connecting Liverpool and Birkenhead, and New York and Brooklyn, by wire suspension bridges of one span; also, remarks on street railways and the application of the suspension principle to correct the inconveniences of the London street traffic; and a suggestion for a viaduct across the Holborn valley, and across the Mersey at Runcorn.

† From the London Engineer, No. 253.

failed from any undulation produced by a passing load, but either from actual insufficiency of section of metal in the cables, or from undulation produced by the action of a hurricane.

The papers published in Vol. III of the "Transactions of the Institute of Civil Engineers," by General Pasley, R.E., on the Montrose Bridge after a hurricane in October, 1838, and by John Provis, Esq., C.E., on the injury to the Menai Bridge in 1839, give valuable information on the effect of wind on suspension bridges.

Mr. Provis and General Pasley both agree in the opinion that the injurious action principally arises from the undulation of the platform, and not from the vibration or oscillation of the chains; and the remedy applied by Mr. Provis was an increase given in the longitudinal stiffness of the platform, which, although not to such extent as my calculations would deem necessary, has been found sufficient to cure the evil, as no further damage has occurred since 1839.

Mr. Provis states in his report that the amount of wave of a previous gale of wind in 1836 was observed by the bridge-keeper to be 16 feet, and there is no doubt the wave of the gale of 1839, which caused the principal damage (which was most severe in the night) was much greater. It therefore might reasonably have been expected that the cables which sustained the succession of blows arising from the momentum of a platform (the total weight of which was 400 tons) falling 16 feet would have sustained injury, and these not being injured, is a proof that this bridge, with a properly constructed metal girder and platform, could be used safely for railway traffic, as the heaviest train on a good road would create less momentum than that produced by the undulation described.

In the Niagara Bridge the injurious action of the wind is amply guarded against. The undulatory action on the platform at the highest calculation will not exceed the weight of a heavy goods train, and as the timber trussing (which is 18 feet deep) is proved to have such girder resistance, that a train will not produce a wave exceeding 3 or 4 inches, there is no fear of an injury from the effect of a hurricane, but to be doubly sure, Mr. Roebling has added 56 wire-rope stays, attached to the lower floor, which are firmly anchored to the solid rock.

These rope stays have been treated in the arguments used against the success of the Niagara Bridge, as forming part of the structure, and as adding to the rigidity; but this is clearly not the case, at all events in the hot season, because the platform of the bridge is lowered above two feet by the expansion, and as the stays will be at the same time lengthened, they will be so loosened as to be inoperative at the period when the greatest traffic occurs. The experiment made by me was in the commencement of August, when the temperature was unusually high even for America, and when they could by no possibility have had any influence on the rigidity.

It is also frequently argued as a proof of the instability of the Niagara Bridge, that its weakness is tacitly acknowleged by the regulations of the engineer, which limit the speed of trains to five miles an hour.

It has been a debated question whether greater deflection in a girder arises from increased speed, and this subject was particularly investigated by the commissioners appointed, in 1849, to inquire into the application of iron to railway structures, and some experiments were made by me at their desire, on the Godstone Bridge of the South-Eastern Railway, of which I was at that time the resident engineer. A scaffold was erected which rested on the road, and was, therefore, unaffected by the motion of the bridge, and a pencil was fixed to the underside of one of the girders of the bridge, so that when the latter was affected by the weight of the engine or train, either placed at rest or passing over it, the pencil traced the extent of the deflection on a drawing board attached to the scaffold. The commissioners report "that the deflection was slightly but decidedly increased when the engine was made to pass over the bridge, and at a velocity of about 50 miles per hour an increase of one-seventh was observed. As it is known that the strain upon a girder is nearly proportional to the deflection, it must be inferred that in this case the velocity of the load enabled it to exercise the same pressure as if it had been increased by one-seventh, and placed at rest upon the centre of the bridge."

Assuming such result to arise from increased speed, there is no reason for not running at 50 miles per hour over the Niagara Bridge, as the heaviest train that can be placed on it does not produce, with the weight of the bridge, a strain equal to $\frac{1}{6}$-th per cent. of the ultimate strength of the cables.

Being of course present at these experiments, and having recorded some of the observations referred to, I formed the opinion, which was concurred with at the time by other engineers, that the increased deflection principally arose from imperfection of the joints, the engine falling through a certain space at each bad joint, and thus producing a blow.

And I have little doubt, if the stability of the structure was the only question, that, if a good fished permanent way was laid over the Niagara Bridge, no more vibration and deflection would be produced at a speed of 50 miles per hour, than now occurs on the present road, which, although perfectly safe, is much worn by the heavy traffic.

But the speed which may be safely adopted in passing a bridge is not a simple question depending alone on the rigidity and strength of the structure. A train may run off the road at a high speed, either from the state of the permanent way or the fracture of an axle or any part of the rolling stock, and every description of girder in such a case would fail. No person who has witnessed a railway accident, and the effect of a collision, will doubt that, under such circumstances, the sides of a tube or lattice girder (on which the stability, as well as on the top and bottom, depend) would be carried away.

And here it may be remarked that a misunderstanding frequently exists as to the momentum of a train in relation to the speed. The mechanical definition of momentum is weight multiplied into velocity, from which it may be supposed that a train at double speed would exert only double the force on any object it came in contact with; but

this is not so. It would require four times the amount of brake power, and would tear away four times the extent of the sides of a lattice or tube girder, to bring it to a state of rest, and therefore the danger from such an accident increases in a rapid ratio in relation to the speed.

As a general rule, such an accident on a suspension bridge would be less fatal, because it is dependent on the sides of the girder for stiffness only, and not for its actual strength. It appears to me, however, that no bridge, whatever its construction, is safe if a train leaves the road at 50 miles per hour, and that in a bridge situated as at Niagara over a chasm 240 feet deep, it is a wise precaution to travel slowly, particularly as little can be gained by increased speed, there being a station immediately on each side of the river, at which every train stops.

In concluding my remarks on the reason of the engineer for adopting an unusually slow speed on the Niagara Bridge, and how far it is to be considered as an acknowledgment on his part of deficiency of strength in the structure, it should be mentioned that it is the customary practice in the United States (inconsistent as it may appear to their supposed disregard of life) not to permit even a single horse to go beyond a walking pace over their road bridges, whatever may be their construction, and a penalty of five dollars is rigidly enforced for any disregard of the rule. I passed over girder, arched, as well as suspension bridges, and found no exception in the rule; and a notice-board is generally put up, as at Niagara, to warn the drivers of the penalty.

Such being the custom of the country, it is imperative on Mr. Roebling to adopt it in a bridge situated as at Niagara; but it cannot be supposed (as between forty and fifty engines cross the bridge every day, and a train of 350 tons with two engines has passed over) that the engineer is afraid to trot a horse over it, and adopts this rule from a fear of the safety of his bridge. And it is, no doubt, under similar circumstances that he adopts the slow speed over his rails as well as over his road.

It appears, therefore, that any impression as to the insecurity of the Niagara Bridge, induced from the caution used by Mr. Roebling in a railway bridge of such extent and in such a situation, is a very unfair one, as the same rules would have been adopted by every American engineer if the bridge had been of half the extent, with no difficulty or novelty in the construction.

*On the Strength of the Niagara Bridge.*

The bridge is supported by four cables, each containing 60·40 square inches, the two upper of which have a deflection of 54 feet, and the lower pair 64 feet. The strain at the points of support, in relation to the weight, will be obtained as follows:

Let $d$ represent the deflection,
$\quad$ W the weight,
$\quad$ S the half span,
and T the tension.

$$\mathrm{T} = \frac{\mathrm{W}}{4\,d}\sqrt{4 \times d^2 + \mathrm{S}^2}, \text{ or,}$$

The cables having different deflections, the strain with a given weight

will vary in each pair of cables, which is undoubtedly a defect in the bridge; because in the summer the lower pair will do the principal duty, and in winter the upper pair. There is, however, such an abundance of strength, that no strain can ever arise on either cable that approaches the limit of elasticity, that the mean deflection of 59 feet will fairly represent the average strain on the cables.

$$\text{Therefore } \mathrm{T} = \frac{\mathrm{W}}{4 \times 59} \sqrt{4 \times 59^2 + 410{\cdot}66^2} = 1{\cdot}81.$$

The total weight between the towers is estimated by Mr. Roebling at 1000 tons, and therefore the strain on the cables from the bridge alone will be 1810 tons. The ultimate strength of the four cables is estimated from actual tests of each wire at 11,904 tons.* The ratio of strength to the ordinary strain will, therefore, be as 6·5 to 1, and the strain per square inch of iron wire, 7·5 tons.

The strength of the iron, being 100,000 lbs. per square inch, as estimated by the engineer, is unusually high; but it is arrived at by actual test, and the metal was of the best quality, as will be seen by reference to the specification.† The capability of manufacturing iron to resist tensile strains, of such superior quality to that used for girders, produces one of the practical advantages of the suspension principle, by reducing the weight of the structure, which in large spans causes the principal strain they have to contend with.

As the weight of the bridge is limited by regulation to 300 tons, the greatest strain on the cables, including the weight of the bridge itself, will not exceed 2380 tons, or under one-fifth of the ultimate strength of the cables, and therefore it is fully of the strength required by the officers of the Board of Trade of this country for railway bridges.

### *On the Durability of the Niagara Suspension Bridge.*

This, like every railway bridge in England, has been subjected to the test of a load exceeding what it can be subjected to in practice; there is, therefore, a margin in every bridge for deterioration of a determined amount, being the difference between the actual test of the bridge and the greatest load it will afterwards receive.

But this is not the only security as to durability. In addition to the margin obtained by actual experiment, there is a much greater intended margin, the security of which as an actual test of strength depends on calculation; that is to say, the ultimate strength of the structure is intended to be much greater than the test applied; and in the case of the Niagara, is estimated to be equal to endure a strain of five times the test applied, including the weight of the bridge itself.

In comparing the durability of railway structures, the certainty of the calculation on which this margin depends is an important element in the question.

With regard to the actual deterioration from oxidation, the progress

* The wire was manufactured by Messrs. Johnsons, of Manchester, England.

† See report of Mr. Roebling, C.E., 1856, in "Public Works, British and American," published by John Weale, 59 High Holborn.

is so slow that its operation in a suspension bridge, where every part can be got at and painted, will not be an appreciable amount. Tube bridges, or any structures composed of thin plates, and cells difficult to be got at, will be more liable to loss of strength from this cause.

Another supposed cause of decay in the strength of iron structures, is the alteration in the mechanical conditions of the fibres of the metal from continual vibration. There is no doubt that violent and continuous vibration of iron will affect its tensile strength after a length of time, but it is clear that it must be of a very severe character to produce any injurious result, because the parts of machinery of various kinds, and none more so than a marine steam engine, have to endure an amount of constant vibration which would soon exhibit itself if iron was readily affected. That steel wire will bear violent vibration without injury is proved by the durability of musical instruments, and the existence of suspension bridges constructed without girders for so many years, in which the most severe vibration occurs in every gale of wind (as is so forcibly described in the report of General Pasley and Mr. Provis), satisfies me that, in a structure like the Niagara Bridge, where the cables are subjected to a moderate tension, and may be said to be free from vibration, their durability will not be less than the masonry of which the towers are built.

In large girders, which are admitted to be of necessity much heavier, and of their own weight to create a larger constant strain on the metal, the destruction will be more rapid. But the feature in girder constructions which to my mind renders their durability doubtful, is the fact that they depend for their strength and safety on the compressive, as well as the tensile resistance of iron, and consequently the estimated margin of strength is more doubtful, because the power of a bar to resist compression is not always correctly measured, as in a tension bar, by the section of metal. As long as a compression bar or tube maintains its figure, its power of resistance is in proportion to the section; but when you have large girders to deal with, and serious compressive strains, no calculation derived from model experiments is to be depended on; an engineer cannot be certain that a few tons in excess of his actual test will not cause buckling and the destruction of the bridge, and therefore there does not exist in girders or arches that certainty of durability that exists in a properly constructed suspension bridge.

Before concluding my observations on the Niagara Bridge, it is necessary to say a few words on its imperfections as well as its good qualities. I have before referred to the two cables having a different amount of deflection, which it appears has arisen from its having been designed in the first instance for road traffic alone. The effect of this is, that the deflection from expansion will be different in the two cables; and thus the principal work is done in the winter by the upper cable, and in the summer by the lower cable. This difference, which amounts to about 2 inches, is not sufficient to bring any serious strain on the cables, but it is calculated to cause an irregularity in the weight on the suspension rods, which may possibly lead to a little inconvenience.

A second objection is, the use of timber for the longitudinal trussing and flooring. It is objectionable from presenting more surface to the action of the wind, but more particularly from much greater weight of material being required to gain a given longitudinal stiffness. Fir timber of a given weight will extend or compress 2·5 times the amount of a similar weight of good wrought iron, although the specific gravity is as 1 to 10; and the parts of an iron truss or girder admit of being secured together so as to retain a larger proportion of the action of the fibres than is the case with wood.

A suspension bridge should have the platform or roadway also of iron, so as to act as a horizontal girder and resist the action of the wind. By the use of iron in the platform and girders, a weight of 400 tons in the place of 600 tons of timber would have reduced the deflection of the wave to one-third, and would have rendered unnecessary any anchorage to prevent the action af the wind.*

A third and final objection applies to nearly all suspension bridges, hitherto constructed, viz., the cables are supported on carriages on rollers, instead of being attached to the towers.

An engineer, when he constructs an arch, would not expect to have a rigid structure if he placed the abutment on rollers, and how can he expect in a suspension bridge to have rigidity if he adopts a similar expedient?

We are apt to follow what has been previously adopted without reflection, and desire to avoid the responsibility of a change of an adopted system; but there is no difficulty in attaching the cables to the towers if they are of iron, and constructed so as to act as vertical girders, to resist the inequality of the weight which may arise on the different spans of a bridge. In fact, you cannot expect perfect rigidity in a suspension bridge as they are now constructed; but there is no reason why they should not be treated like an arch reversed; and if they were so treated there is nothing in the suspension principle to render them less rigid.

There is, however, no intention to imply, by these observations, that the Niagara Bridge is less durable from these omissions to any appreciable extent. I believe, provided the timber and masonry are kept in repair, it will last for hundreds of years, and that a certain degree of motion in a bridge does not affect its strength or durability, provided no strain in any part exceeding the elasticity is produced; at the same time, by the means pointed out, the undulation and vibration, small as it is, would be considerably reduced.†

(To be Continued.)

* The towers should also be of iron, in order that the expansion may correspond with that of the suspension rods. The suspension rods should be at right angles to the cables, and fewer in number, by which the tremor as well as the undulation will be reduced.

† See the report of Mr. Roebling, C.E., in the *Engineer*, September 21, 1860, and *Jour. Frank. Inst.*, vol. xl., Dec., 1860., p. 361.

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## *Query respecting Suspension Bridges.*

To the Editor of the Journal of the Franklin Institute.

SIR:—I may be mistaken (and if so, shall be glad to have my error corrected) in believing that the design for a suspension bridge of four

spans of one thousand feet each, and two spans of five hundred feet each, which I prepared early in the year 1851 immediately after my return from the Panama Railroad, and which was exhibited for several months of that year in the reading-room of your Institute, was the first proposition for applying that principle to railroad purposes on a large scale. The design (which is fresh in the memories of many visitors at your rooms) was prepared with the object of showing the practicability of uniting the Philadelphia and Columbia Railroad of Pennsylvania with the Camden and Amboy Railroad of New Jersey by crossing the River Delaware at Market Street, Philadelphia, without either obstructing the navigation of the river, or incurring an excessive expense. The entrance to the bridge on the Philadelphia side was at Second Street; and the floor was placed 100 feet above high water, so that the few large vessels which ascend above Market Street could pass with ease by striking their top-gallant masts; a very simple operation requiring but a few minutes to perform. The rigidity of the bridge was provided for on the same general principle as in the Niagara Suspension Bridge built since that time; namely, by strong timber trussing about twenty feet deep, put together on the system well known as the, so-called, Burr's plan, but omitting the wooden arches. The entire design was very much the same as I should now adopt if called on to plan such a bridge. My drawing was also placed in your annual exhibition of 1851; and was afterwards removed to the public room of the Merchants Exchange, where it remained for several months; and from which it was taken during my absence in South America engaged in the exploration of Humboldt's proposed interoceanic canal routes in 1852. It elicited one or two notices in the newspapers of the day; but was very generally regarded as a chimerical proposition. I have never been able to ascertain by whom it was removed. If this notice should meet the eye of any person acquainted with its present whereabouts, he will confer a favor by informing me of it.

John C. Trautwine.

Philadelphia, Dec. 7, 1860.

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## MECHANICS, PHYSICS, AND CHEMISTRY.

For the Journal of the Franklin Institute.

### *Alloys of Cadmium.* By B. Wood, M. D.

In a former communication,* I took occasion to speak in general terms of some of the properties of cadmium as exhibited in combination with other metals, in order to draw attention to certain characteristics which appeared to have been overlooked heretofore. I now propose to speak of some of its specific combinations by way of illustrating its properties in particular connexions. I confine myself to the results of my own experiments.

These experiments were made at different periods, as occasion

* Journal of the Franklin Institute for August, 1860, page 113.

prompted, with a view to the production of alloys possessing properties suitable for particular uses. Although they cannot but fall short in value to what a more methodical investigation might have educed, it is hoped they may not be altogether without interest.

*Cadmium* in its general characters has a greater resemblance to tin than to other metals. It has less lustre, tarnishes more readily in the atmosphere, is considerably harder, and requires a higher heat for its fusion. It has a sort of milk-white glistening color, approaching a silver-white, with a blue tinge, somewhat like zinc. Its melting point is nearly the same as that of lead. At a low red heat it volatilizes, giving off orange-colored fumes; at a higher heat it flashes and detonates, and if the heat be still raised it bursts into flame with an explosion. It is perfectly malleable, and has considerable tenacity.* In flexibility or toughness, or coherence of its particles, as indicated by flexion and torsion,† it is inferior to tin, ranking with lead. It dissolves rapidly in nitric acid, is acted on feebly by muriatic acid, and very slightly by sulphuric acid. (Neither of the last named acids evinced a perceptible action immediately; after remaining some hours in strong muriatic acid, the metal became blackened, small bubbles (hydrogen) clinging to the surface, and a minute quantity of black particles being detached from it; immersed the same length of time in sulphuric acid, the surface of the metal was not perceptibly discolored, though slightly clouded, presenting a "deadened" appearance; no bubbles were visible.)

It tarnishes at once in strong solution of caustic potash, but the *solvent* action of this menstruum upon it appears to be very feeble.

Electrically, it is highly positive with respect to gold and silver. When pieces of gold and cadmium, placed on opposite sides of the tongue, are brought in contact in the usual method, a powerful galvanic action results, producing a remarkably pungent, disagreeable, and persistent taste, with a sense of excoriation of the tongue and even lips. The impression produced by cadmium and silver in the same way, is also very pungent, but the taste is not so disagreeable.

With some metals, cadmium appears to have little affinity; with others, its affinity is very strong.

Its volatility renders its combination with the less fusible metals somewhat difficult under ordinary circumstances, although probably not in general more so than is the case with zinc.

*Cadmium* and *Copper* have too little affinity to alloy well. It is difficult to make them unite by means of the blow-pipe;‡ the process

* Phillips, Manual of Metallurgy, ranges it in the order of malleability, below tin, but above lead; in ductility below both. I do not remember having seen its tenacity indicated. What I mean by "perfect," as applied to malleability, is that the metal is susceptible of being hammered down to thin plates without any cracks or breaks at the edges.

† I am at a loss for a good term to denote this quality, or the amount of flexion which metals in the form of bars are enabled to endure before breaking. The flexibility or toughness of the following metals, as indicated by bending at right angles back and forth, is represented by the order in which they are named, to wit: 1, Tin (the most flexible of metals); 2, Gold (pure); 3, Platinum; 4, Cadmium and Lead; 5, Silver; 6, Copper; 7, Zinc.

‡ The experiments detailed in the present paper were made with the common blow-pipe, upon a charcoal support, using borax to promote union, and to prevent volatilization of cadmium. As a further precaution against volatilization, the cadmium should be kept a little separate from the other metal (or alloy), directing the jet of flame at first upon the latter until melted, or at least heated to redness, which in most cases will suffice, when the two are to be brought quickly in contact.

must be managed with care; it is generally attended with crackling, and much volatilization of cadmium. If copper be used in excess, the alloy is likely to be porous or cavernous, presenting a spongy structure, owing to the retention of vaporized particles of cadmium which refused to enter into combination. On remelting the compound, a portion of the cadmium volatilizes and extricates itself, bubbling up through the fused mass, and on this again cooling and solidifying, jagged protrusions break through the crust, like scoria. So, too, if brought to a red heat, though not melted, a portion of the cadmium oozes out and escapes in fumes. When, however, cadmium is in excess, the union is more intimate and perfect, the structure of the alloy being compact throughout.

3 parts (by weight) of cadmium and 1 part copper, form a white, brittle alloy, of compact and homogeneous structure. It breaks like glass at a tap of the hammer, with a pearl-like fracture, presenting smooth glistening facets of a very clear white color, resembling very nearly the fractured surface of antimony, but surpassing it in brilliancy. Upon exposure to the atmosphere, its surface acquires a yellow tinge. It melts at a red heat, or at about the melting point of antimony.

1 part cadmium, 1 copper.—A brittle, yellowish-white alloy, breaks under a light blow with a granular fracture. Upon exposure, the surface assumes a deep yellow color.

1 cadmium, 2 to 4 copper. The metals in these proportions combine imperfectly under the blow-pipe. The compounds are brittle or but slightly malleable, and have a red copperish color.

*Cadmium* and *Platinum* combine at a full red heat, with a sort of explosion (?). It was difficult to form this alloy with the blow-pipe. The cadmium fumed, crackled, and burned, in spite of any management; and when combination took place, the percussion was such as to blow the mass from the support. Melted in a crucible under borax, there was a slight detonation, but no combustion or fumes.

1 cadmium, 1 platinum, form a hard, brittle alloy, breaking at a tap of the hammer with a crystalline fracture, of a gray color, having a purplish tint resembling bismuth.

1 cadmium, 3 platinum: similar to the last in character and appearance, but still more brittle, shattering to fragments under a slight blow. It has a clear gray color, and a higher metallic lustre than the preceding.

*Cadmium* and *Nickel.* With nickel I could not effect a combination, the metals appearing to have no affinity whatever, the cadmium burning away, and the nickel not the least affected.

Tin and nickel under the same circumstances combine, forming an iron-gray brittle compound.

*Cadmium* and *Silver* unite readily by the blow-pipe, with little tendency on the part of the cadmium to volatilize; showing a strong affinity between the metals.

1 cadmium, 1 silver (pure), form a gray-white alloy, of the color of platinum with a violet shade. It is very hard to the knife. It has a

firm homogeneous texture. In hammering, it evinces considerable malleability, but is disposed to cleave under repeated blows. If annealed during the process, it is highly malleable. When condensed by hammering, it breaks easily, presenting a close-grained fracture; but when previously annealed, it bears flexion back and forth nearly as well as copper.

2 cadmium, 1 silver. Very hard, superior to zinc in this respect. Color bluish-gray similar to that of zinc, but has more lustre. Not malleable, cracking through the centre with a coarse fracture.

1 cadmium, 2 silver. This is also a very hard alloy, apparently harder than the last mentioned. It has a yellowish-white color, with a beautiful violet hue. It is perfectly malleable, and has great tenacity. The difficulty with which it fuses is remarkable, particularly in view of the common theory as to the fusibility of alloys. Tested by the side of ordinary silver solder on silver plate, it did not melt under the heat which flowed the solder, and only when the silver began to melt. It is nearly tasteless.

2 cadmium, 3 silver. Similar to the last in general characters, but in color approximates more to a true yellow.

*Cadmium*, *Silver*, and *Tin*. Alloys consisting of 1 cadmium, 2 silver, 4 tin; and 2 cadmium, 1 silver, 2 tin, are hard, malleable, and possess considerable tenacity.

*Cadmium* and *Gold* combine perfectly and with remarkable readiness. Properly managed, the union takes place without hissing, crackling, or detonation (as I was led to anticipate from the cases of copper and platinum), and the cadmium shows no disposition to escape by volatilization. The affinity of these metals is extraordinary. No sooner is the cadmium brought in contact with the melted gold than the metals seem literally to leap into each other's embrace, blending instantly into a homogeneous compound. Their compounds appear to fuse at a temperature less than the mean of the melting point of the constituents.

1 cadmium, 2 gold (pure), unite perfectly and with great facility (as above described), forming a splendent round button; color, white with a yellow tinge. Very hard to the knife. Not malleable, breaking through the centre with a crystalline fracture.

The alloys with gold continue brittle until the cadmium is reduced to one-eighth part or less.

1 cadmium, 9 gold. This is of a greenish-yellow or brass color. Very malleable if annealed during the process of hammering. In toughness or flexibility similar to copper. Its fusibility is nearly the same as ordinary 18 carat gold.

*Cadmium*, *Gold*, and *Silver*. The addition of silver to alloys of gold and cadmium increases their malleability, but diminishes their fusibility.

1 cadmium, 9 gold, 2 silver. In color this resembles the last named, although somewhat paler. It is perfectly malleable, hammering out thin, with smooth, unbroken edges. It is infusible at the melting point of 20 carat gold, but melts and flows on pure gold. It will be

observed that this and the preceding case furnish results different from what generally holds good in respect to gold alloys, the fusibility of which is usually increased by lowering the standard of fineness, and also, the standard remaining the same, by multiplying the number of constituents, especially when each of these is less fusible than gold. Thus, 18 carat gold melts more easily than 20 carat, and 16 carat more easily than 18. Again, gold of the same standard, say 18 carat, is more fusible when alloyed with both silver and copper than when alloyed with but one of these metals. But the alloy last described, although both lower in standard and having a greater number of constituents than the one preceding it, requires a much higher heat for its fusion.

*Cadmium, Gold*, and *Copper.* The compounds of these metals are interesting on account of their fusibility; the most decided effect, other qualities considered, being produced when nearly equal proportions of copper and cadmium are used in the combination with gold. It is worthy of note that, whereas silver added to compounds of cadmium and gold raises the melting point, copper, although less fusible than silver, lowers it.

1 part cadmium, 4 copper, 25 gold (bringing the gold to the standard of 20 carat), form a very malleable alloy, of a tawny copper color. It is but little more fusible than 20 carat gold alloyed with copper and silver.

1 cadmium, 1 copper, 10 gold (equal to 20 carat gold). An orange colored alloy; hard, malleable, and tenacious. It has a pungent, disagreeable, "brassy" taste. It melts and flows with facility on 16 carat gold solder, and also on silver plate; but is less fusible than silver solder. In practice, it is required for safe working that gold solder (alloyed with copper and silver in proportions insuring the greatest fusibility) should be at least 4 carats below the standard of the gold on which it is to be worked. But the reverse holds in the examples just cited, even when the same constituents are used, if only used in different proportions.

The melting point of the alloy is further lowered by reducing the proportion of gold, but this impairs the qualities of malleability and tenacity.

Equal parts of cadmium, copper, and gold, produce a silver-white, brittle alloy, which cleaves asunder under a smart blow, presenting a granular fracture. It melts below a red heat, a little above the melting point of zinc, but below that of antimony.

*Cadmium, Gold, Copper*, and *Silver.* Silver added to combinations of cadmium, gold, and copper, promotes tenacity and diminishes fusibility, but less decidedly than in the case of compounds of gold and cadmium. By varying the proportions of these four metals, the different varieties of gold color may be imitated.

1 cadmium, 1 copper, 2 silver, 20 gold (fineness 20 carats). A bright "yellow-gold" color. Perfectly malleable. Much less fusible than ordinary 20 carat gold.

1 cadmium, 2 copper, 1 silver (20 carat). Color nearly that of pure gold. Malleable. Somewhat more fusible than 20 carat gold.

1 cadmium, 1 copper, 2 silver, 12 gold (18 carat). Very malleable. A rich yellow color. Similar in fusibility to the last.

1 cadmium, 2 copper, 1 silver, 12 gold (18 carat). Malleable. Nearly a pure gold color. Melts readily on gold solder. Barely melts on silver plate. This is somewhat less fusible than gold alloyed to 20 carat standard by the use of equal parts of cadmium and copper. It is liable to the same objection of having a "brassy taste"—a characteristic which appertains to all alloys of gold, no matter how fine, which contain both cadmium and copper.

The quantity of gold may be further reduced in the above formulæ without perceptible damage in respect to color.

*Cadmium*, *Copper*, and *Silver*. It is curious to observe the rich and varied colors exhibited by the different combinations of these metals.

In their physical properties these alloys are all hard. If silver, or silver and copper, be in excess, they are malleable. If cadmium, or cadmium and copper, be much in excess, they are brittle. But in either case, they have greater malleability than might have been expected, judging from the brittleness of the mixtures of cadmium and copper. We witness here the remarkable effect of silver as a bond of affinity between these two metals, in promoting their union and changing the character of the joint result.

Equal parts cadmium, copper, and silver, unite readily with very little volatilization of cadmium. The alloy is harder than that of equal parts of silver and cadmium, and nearly the same or somewhat superior in malleability and tenacity, being highly malleable and possessing considerable strength. It has a pale, pinkish-yellow color. If cadmium be somewhat in excess, the malleability is impaired, and the color approaches more to violet.

1 cadmium, 1 copper, 2 silver. Combination takes place with facility. A very handsome alloy, compact in texture. Perfectly malleable, and has great tenacity, resembling in these respects the alloy consisting of 1 part cadmium, and 2 parts silver. Color, yellowish-white, with a golden hue.

1 cadmium, 2 copper, 1 silver. These proportions do not combine so readily as in the two preceding cases. In respect to malleability and tenacity, the alloy is somewhat inferior to the first named, but superior to the last. Color, pale copperish-red, or pink. An alloy of 1 cadmium, 3 copper, 2 silver, has a redder color, but is very similar in other qualities.

5 cadmium, 3 copper, 4 silver. This is but slightly malleable. It possesses a fine lilac color.

2 cadmium, 1 copper, 3 silver. Perfectly malleable. Color, a beautiful light violet.

3 cadmium, 1 copper, 2 silver. But slightly malleable. It has a very rich violet color.

Thus it appears, by different proportions of these metals, we produce all the richer tints of the rainbow—the various combinations of violet, yellow, red. These alloys admit of a high polish, and,

doubtless, some of them would prove valuable substitutes for silver, for certain uses.

In these descriptions, it has appeared necessary to deal with specific proportions, in a variety of forms. We cannot rely upon generalization, nor upon what is predicated upon single instances, as to the behavior and products of metals in combination with others. Descriptions not based upon any specific formula convey little or no positive information, and may lead into error. When but a single formula is given, or if, when none is given, we are to take equivalent proportions as being intended, the facts frequently show, at every considerable departure on either side from the formula given or intended, results essentially different from those described.

In another paper, I propose to speak of some of the combinations of cadmium with the softer metals.

Nashville, Nov. 24, 1860.

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## *Electric Zincing:* Process of MM. Person and Sire.

In one hundred parts of water, dissolve 10 parts of alum and one part of oxide of zinc; this is the zincing bath, and it is well to keep it at 15°. The pieces which it is designed to zinc, being first cleansed, are so arranged as to constitute the negative pole of a pile; at the positive pole, are piled one or two sheets of zinc, having the form of the pieces to be zinced, and about the same dimensions. The poles of the pile thus disposed are plunged into the alum bath. By the action of a current of a single element, whose size increases with the size of the pieces to be zinced, the reduction of the zinc is accomplished as easily as that of copper in galvano-plating, and its deposit takes place indifferently on all metals, as well upon platina as on copper or iron.

When the zinced copper is heated, a coating of brass is formed, and this may receive various applications. Raising the temperature of the zinced iron increases the adhesion of the coating of zinc. MM. Person and Sire affirm that the thickness of the coating increases proportionally to the time: that the reduced zinc has all the properties of the purest zinc, and that it completely prevents the oxidation of the object covered with it.—*Cosmos,* November, 1860.

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For the Journal of the Franklin Institute.

## *Particulars of the U. S. Steamer Dacotah.*

This vessel was one of the seven second-class sloops recently built by the Government.

The hull was built at the Navy Yard, Norfolk, from the design of the late Samuel T. Hartt.

The engines were constructed by Messrs. Murray and Hazzlehurst, of Baltimore. The contract for the machinery required a speed of 14 miles per hour with an additional compensation for a speed of 15 sta-

tute miles per hour for six consecutive hours. The following are the principal dimensions:

HULL.—Length between perpendiculars, 198 ft. 6 ins. Do. for tonnage, 227 ft. Extreme breadth, 32 ft. 9 ins. Depth of hold, 9 ft. 3½ ins. Draft of water, 13 ft. Tonnage, 1150 46-95 tons. Displacement at above draft, 1368·74 ft. Area of immersed section, 365 sq. ft. Do load water line, 2663 sq. ft.

ENGINES.—Two horizontal geared engines. Diameter of cylinder, 5 ft. 3 ins. Length of stroke, 3 ft. Diameter of crank shaft, 1 ft 1 in. Do. of screw do., 10¼ ins. Do. of spur wheel, 8 ft. Do. of pinion, 3 ft. 6 ins. Proportion of gearing, 2·23 to 1. Maximum pressure of steam, 35 lbs. Do. revolutions, 35.

The engines are fitted with independent steam and exhaust slide valves. The expansion of steam is effected by the link motion, which is regulated by an adjustable attachment.

Two surface condensers. Number of tubes in each, 2856. External diameter of do., ⅝-in. Length of do., 4 ft Thickness of tube-sheets, 1 in. Diameter of air pump, 1 ft. 8 ins. Length of stroke, 3 ft.

Two air pumps double-acting, one side being used for fresh water and the other side salt water. The steam is condensed upon the outside of the tubes. One end of the tubes is made fast, the other passing freely through the other sheet, but is packed with gum washes according to the patent of William Sewell, Esq.

BOILERS.—Two.—Horizontal tubular. Length of boilers, 10 ft. 6 ins. Breadth of do., 24 ft. 6 ins. Height do., exclusive of steam chimney, 10 ft. 3 ins. Do., inclusive of do., 14 ft. 3 ins. Total number of furnaces, 16. Width of eight do., 2 ft. 10 ins. Do., 1 ft. 10 ins. Length of grates, 6 ft. 4 ins. Number of tubes, 896. External diameter of do., 3 ins. Length of do., 7 ft. 6 ins. Total grate surface, 268 sq. ft. Do. heating surface, 6800 sq ft. Steam room, 1300 cub. ft. Diameter of smoke pipe, 7 ft. Height of do. above grates, 41 ft.

PROPELLER.—Diameter, 12 ft. 6 ins. Length at hub, 2 ft. Do. at periphery, 2 ft. 3 ins. Number of blades, 3.

At the hub the pitch is that of a true screw of 17 feet pitch. At the periphery the pitch expands from 17 to 19 feet.

Although the engines are geared they are not above the water line—the centres of the spur wheel and pinion being in the horizontal line through the centre of the cylinder. This is accomplished by making the after connecting-rod in two parts—separated to allow the shaft to pass through and permit the vibration of the rod with the revolution of the crank.

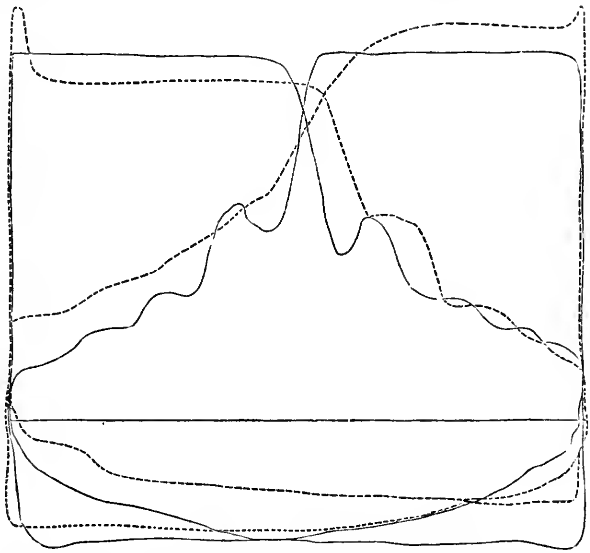
The eccentrics work upon a shaft separate and above the crank shaft, to which motion is communicated by means of gearing. The screw shaft passing through the dead wood is covered with brass and is fitted with lignum vitæ bearings. The shaft is fitted with a cone thrust and the ordinary collar thrust.

The bunkers stow 240 tons of coal. The weight of machinery, spars, and water in boilers, &c., is 277·76 tons.

In accordance with the contract, the vessel passed a satisfactory trial at sea for one week, and during four consecutive hours maintained a speed of 13·2 knots or 15·24 statute miles per hour. The following

is a specimen of indicator diagrams taken at the above speed. Date May 30th, 1860, 2 hours 30 minutes, P. M.

| | After Engine. (full lines.) | Forward Engine. (dotted lines.) |
|---|---|---|
| Revolutions per minute, | 35 | 35 |
| Pressure of steam, | 32 | 32 |
| Vacuum, | 25 | 25·5 |
| Throttle, | Wide open. | Wide open. |
| Mean pressure, | 29·16 | 28·8 |
| Horse power, | 578·43 | 571·29 |



An abstract from her log shows a consumption of 2·81 lbs. of coal per hour per horse power. The contract specified that the consumption shonld not exceed 2·9 lbs.

Armament.—Two 11-inch pivot guns and four 32-pounder guns.

The *Dacotah* is now attached to the squadron for the East Indies and China Seas. J. H. W.

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For the Journal of the Franklin Institute.

## *Power required to Overcome the Resistance of the Feed Pumps of the U. S. S. Frigate Powhatan.* By Wm. H. Shock, Chief Engineer, U. S. Navy.

I was anxious to ascertain with some degree of certainty the amount of power required to overcome the resistance of the feed pumps of the *Powhatan*, and, as preliminary to that investigation, the annexed plate of diagrams was taken under different conditions of the check valves on the boilers, as follows:

Check valves wide open.
" at usual working point.
" close shut.

I deemed these three points sufficient for the investigation, thinking that any deviation from them in practice would not materially modify

the result. In this I was correct, as will be seen upon examination of the diagrams, and the tabulated H. P. deduced therefrom.

The average pressure of steam, revolutions, &c., &c., were taken from the daily engine diagrams, and were as follows:

| | |
|---|---|
| Steam per gauge, | 11⅓ lbs. |
| Revolutions per minute, | 9·3 " |
| Vacuum, | 25 inches. |
| Hot-well, | 120° |

DIMENSIONS OF PUMPS, &C.

| | |
|---|---|
| Diameter of pumps, | 8 inches. |
| Stroke of " | 42 " |
| Diameter (internal) of feed pipes, | 4¼ " |
| Weight on safety feed valve, | 294 lbs. |
| Pressure per square inch on safety feed valve, | 20·7 " |

From diagrams 1, 2, 3, &c., Plate I, it is found that the power necessary to overcome resistance of feed pumps was as follows:*

| | | | |
|---|---|---|---|
| No. 1 | = 1·12 | horse powers. | |
| " 2 | = 1·19 | " | |
| " 3 | = 1·58 | " | Check valves at their usual working lift. |
| " 4 | = 1·48 | " | |
| " 5 | = 1·73 | " | |
| " 6 | = 1·54 | " | |
| Mean, | 1·44 | " | |

As the investigation was to ascertain more particularly the power absorbed by the pumps under their normal working condition, we shall use those diagrams only which were taken at that time, and assume their mean resistance to be the measure of power absorbed by each pump, as follows:

| | | |
|---|---|---|
| No. 3 | = 1·58 | H. P. |
| " 4 | = 1·48 | " |
| C | = 1·52 | " |
| D | = 1·70 | " |
| Mean, | 1·57 | " |

And $1{\cdot}57 \times 4 = 6{\cdot}28$ H. P. as the total resistance of the four pumps. The engines at the time were developing 527·58 H. P., 6·28, or 1·19 per centum, of which was being absorbed by the feed pumps.

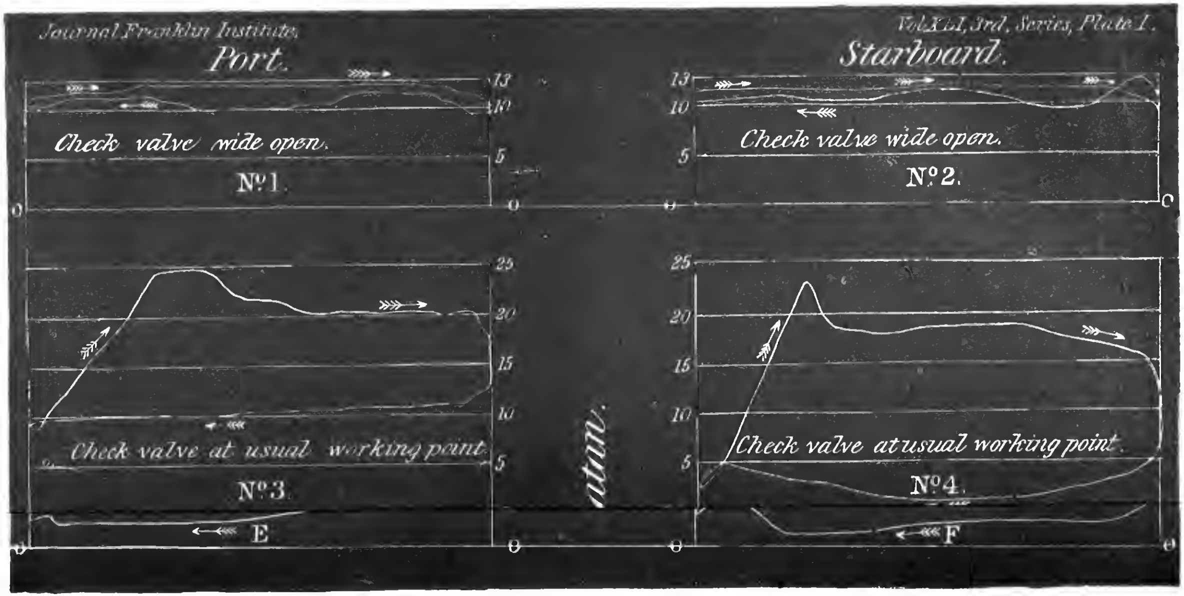
Diagrams A, B, C, &c., were taken under nearly the same conditions of steam, revolutions, &c., &c.

The following tabulated statement shows the pump resistance as determined by each diagram on that day:*

| | | | |
|---|---|---|---|
| A | = 1·23 | horse powers. | |
| B | = 1·26 | " | |
| C | = 1·52 | " | Check valves at their usual working lift. |
| D | = 1·70 | " | |
| E | = 1·58 | " | |
| F | = 1·91 | " | |
| Mean, | 1·53 | " | |

When Plate of diagrams A, B, C, &c., was taken, the engines were developing 600 horse powers, 1·045 per centum of which was exhausted in overcoming the resistance of the pumps.

* It will be observed that the *friction* resistance of the pump plungers, is not an element in the above calculations, not because it was of no importance, but simply from the fact that it was impossible to arrive at a correct estimate of its value. In properly managed pumps, however, loss from this source would be comparatively small.


Port.
Starboard.
Check valve wide open.
No. 1.
Check valve wide open.
No. 2.
Check valve at usual working point.
No. 3.
E
Check valve at usual working point.
No. 4.
F
atan.
13
10
5
0
25
20
15

*Results of Experiments on the Tensile Strength of Copper, Iron, Gun Metal, Yellow Metal, and Bolts.* Made at the U. S. Navy Yard, Washington, D. C., by Wm. M. Ellis, Engineer and Machinist. Tabulated and Reduced by C. H. Haswell.

| No. of Test. | Material. | Diameter. | Length. | Reduction of diameter. | Extension of length. | Breaking Weight. | Mean Strength. | Cohesive strength per sq. inch. |
|---|---|---|---|---|---|---|---|---|
| | | Inch. | Feet. | Inch. | Inch. | lbs. | | |
| 1 | Copper. | $\frac{5}{8}$ | 3 | | 1 | 10,400 | | |
| 2 | " | $\frac{5}{8}$ | 3 | $\frac{1}{8}$ | 1 | 12,100 | 11,900 | 38,567 |
| 3 | " | $\frac{5}{8}$ | 3 | $\frac{1}{8}$ | | 13,200 | | |
| 1 | " | $\frac{3}{4}$ | 3 | $\frac{1}{8}$ | | 15,700 | | |
| 2 | " | $\frac{3}{4}$ | 3 | | | 18,100 | 17,600 | 39,820 |
| 3 | " | $\frac{3}{4}$ | 3 | $\frac{1}{4}$ | | 19,000 | | |
| 1 | " | 1 | 3 | $\frac{1}{8}$ | | 29,900 | | |
| 2 | " | 1 | 3 | $\frac{1}{8}$ | | 29,700 | 29,700 | 37,834 |
| 3 | " | 1 | 3 | | | 29,500 | | |
| 1 | " | $1\frac{1}{8}$ | 3 | | | 26,400 | | |
| 2 | " | $1\frac{1}{8}$ | 3 | | | 32,400 | 29,600 | 29,780 |
| 3 | " | $1\frac{1}{8}$ | 3 | | | 30,000 | | |
| 1 | " | $1\frac{1}{4}$ | 2 | | | 41,000 | | |
| 2 | " | $1\frac{1}{4}$ | 2 | | | 41,500 | 41,833 | 34,093 |
| 3 | " | $1\frac{1}{4}$ | 2 | | | 43,000 | | |
| 1 | Iron. | $\frac{5}{8}$ | 3 | 1-16 | 4 | 16,800 | | |
| 2 | " | $\frac{5}{8}$ | 3 | $\frac{1}{8}$ | 4·5 | 17,300 | 17,066 | 55,590 |
| 3 | " | $\frac{5}{8}$ | 3 | | 4·5 | 17,100 | | |
| 1 | " | $\frac{3}{4}$ | 3 | | 1·75 | 21,500 | | |
| 2 | " | $\frac{3}{4}$ | 3 | | | 24,100 | 24,500 | 55,429 |
| 3 | " | $\frac{3}{4}$ | 3 | 1-16 | | 27,900 | | |
| 1 | " | 1 | 3 | $\frac{1}{4}$ | 5·5 | 43,100 | | |
| 2 | " | 1 | 3 | | | 39,900 | 41,533 | 52,908 |
| 3 | " | 1 | 3 | | | 41,600 | | |
| 1 | " | $1\frac{1}{8}$ | 3 | | | 44,000 | | |
| 2 | " | $1\frac{1}{8}$ | 3 | | | 50,000 | 44,866 | 45,136 |
| 3 | " | $1\frac{1}{8}$ | 3 | | | 40,600 | | |
| 1 | " | $1\frac{1}{4}$ | 2 | 1-16 | 2·5 | 62,600 | | |
| 2 | " | $1\frac{1}{4}$ | 2 | | | 64,200 | 64,200 | 52,322 |
| 3 | " | $1\frac{1}{4}$ | 2 | | | 65,800 | | |
| 1 | *Gun metal. | 1 | 3 | | | 15,300 | 13,550 | 17,388 |
| 2 | " | 1 | 3 | | | 11,800 | | |
| 1 | †Yellow metal. | $\frac{5}{8}$ | 3 | | 3 | 15,000 | 15,750 | 51,302 |
| 2 | " | $\frac{5}{8}$ | 3 | $\frac{1}{8}$ | | 16,500 | | |
| 1 | " | $\frac{3}{4}$ | 3 | 9-16 | 3 | 25,800 | | |
| 2 | " | $\frac{3}{4}$ | 3 | | | 21,500 | 23,000 | 52,036 |
| 3 | " | $\frac{3}{4}$ | 3 | | | 21,700 | | |
| 1 | " | 1 | 3 | $\frac{1}{8}$ | 9 | 44,500 | | |
| 2 | " | 1 | 3 | $\frac{1}{8}$ | | 38,800 | 40,500 | 51,460 |
| 3 | " | 1 | 3 | $\frac{1}{4}$ | | 38,200 | | |
| 1 | " | $1\frac{1}{8}$ | 3 | | | 45,800 | 43,600 | 43,883 |
| 2 | " | $1\frac{1}{8}$ | 3 | | | 41,400 | | |
| 1 | " | $1\frac{1}{4}$ | 2 | 1-16 | 3 | 58,200 | | |
| 2 | " | $1\frac{1}{4}$ | 2 | | | 46,200 | 55,066 | 44,878 |
| 3 | " | $1\frac{1}{4}$ | 2 | 3-16 | | 60,800 | | |

* 9 Copper, 1 Tin.
† " "

| | | |
|---|---|---|
| Mean results of above, | Copper, | 36,000 lbs. |
| | Iron, | 52,250 " |
| | Gun metal, | 17,400 " |
| | Yellow metal, | 48,700 " |

For the Journal of the Franklin Institute.

## *On the Breaking Weight of Iron.*

Hodgkinson, in his valuable work on cast iron, published in 1846, gives the following formula for calculating the breaking loads in tons of solid cast iron cylindrical columns, with flat ends; and not less than 30 diameters in height or length,

$$42 \cdot 2 \frac{d^{3 \cdot 6}}{L^{1 \cdot 7}},$$

and in the Philosophical Transactions of the Royal Society, Part 2, 1840, he gives for similar columns of wrought iron,

$$133 \frac{d^{3 \cdot 6}}{L^{2}}.$$

In both cases, the diameter, $d$, is in inches; and the length, L, in feet. In the last, indeed, he uses $d^{3 \cdot 55}$ instead of $d^{3 \cdot 6}$; and 133·75 instead of 133. The foregoing substitutions, however, do not affect the results to any important extent. From these two formulæ I have calculated the two following sets of breaking loads in tons for columns 3 inches in diameter.

| Length in Feet. | Cast Iron. | Wrought Iron. |
|---|---|---|
| | Tons. | Tons. |
| 8 | 67·2 | 108· |
| 10 | 46· | 69·4 |
| 12 | 33·8 | 48·2 |
| 14 | 26· | 35·4 |
| 16 | 20·7 | 27·1 |
| 18 | 16·9 | 21·4 |
| 20 | 14·2 | 17·3 |
| 22 | 12· | 14·3 |
| 24 | 10·4 | 12· |
| 26 | 9·1 | 10·2 |
| 28 | 8· | 8·84 |
| 30 | 7·1 | 7·71 |

Now, Mr. Hodgkinson tells us in his work on cast iron, that in *long* columns (by which he means those which are 30 diameters, or more, in height), wrought iron is stronger than cast in the proportion of 1¾ to 1; and this is reiterated in all our modern books on the strength of materials, in order that unlettered practical men, like myself, may at once obtain the strength of a wrought iron column from a table of cast iron ones, by merely adding 75 per cent. to the latter. But you will perceive that no such proportion exhibits itself in the foregoing calculations. Again, in the *Civil Engineer and Architect's Journal*, vol. 9, page 308, year 1846 (the same in which Mr. Hodgkinson's work on cast iron appeared), he says that in *long* columns, wrought iron is stronger than cast as 5 to 1·4. Now, the range between 1¾ to 1, and 5 to 1·4, is a tolerably wide one for the best authority we have on the subject, and scarcely definite enough for even a practical

man; but unfortunately neither of these proportions is even approximately borne out by the calculations. This, however, is probably my own fault, owing to some misconception on the subject, which I have not the requisite knowledge to correct.

Professor Rankine tells us in his "Applied Mechanics," that at 60 diameters in height, wrought iron columns have twice the strength of cast; and at 80 diameters, $2\frac{1}{2}$ times; making the ratio in favor of wrought iron to increase with the length, which is undoubtedly correct. But the ratio of strengths in the foregoing columns of my table becomes less favorable to wrought iron as the height increases. Thus, at 15 feet or 60 diameters, we have 32 to 23; at 20 feet or 80 diameters, 17 to 14; and at 30 feet or 120 diameters, 7·7 to 7·1.

By reference to the volume of the Philosophical Transactions before alluded to, I see that Mr. Hodgkinson tried but two experiments on plain solid wrought iron columns of the kind of which I am speaking, namely:

| Length in inches. | Length in feet. | Diameter in inches. | Breaking weight in pounds. |
|---|---|---|---|
| $90\frac{3}{4}$ | 7·563 | 1 02 | 5280 |
| $60\frac{1}{2}$ | 5 042 | 1 02 | 12990 |

and on applying his formula, I find that it agrees exceedingly well with these two results: a natural consequence of its having been based upon them.

Since the introduction of both cast and wrought iron in buildings and in bridges is now becoming very general in the United States, it is essential that our practical men should have the results of the most reliable experiments laid before them in a simple form adapted to their purposes and comprehensions. It is under that plea that I ask the insertion of this crude communication in your valuable *Journal*, in the hope that it may enlist the interest of some one of your scientific readers, and induce him to relieve not only myself, but many others, from the embarrassment in which our ignorance on this important subject involves us. Writers possessed of the high mathematical attainments which distinguish Mr. Hodgkinson, and render him so pre-eminently qualified to investigate so difficult a subject, frequently make too little allowance for the more restricted powers of the very class of men to which their conclusions would be most useful; and therefore express their results in a language which, although very clear to persons of like qualifications to their own, is an unknown tongue to those of more limited requirements, like myself. I take it for granted that my difficulty in the present instance arises from this source alone.

To save as much trouble as possible to any one who may have the kindness to look into this matter and set me right, I add a few of the preliminary calculations as I employed them.

$d^{3\cdot6}$ power of 1·02 is 1·074.

" of 3· is 52·2.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $L^{1.7}$ power of | 8 | ft. is | 34·3 | $L^{1.7}$ power of | 20 | ft. is | 162·8 |
| " | 10 | " | 50·12 | " | 22 | " | 191·5 |
| " | 12 | " | 68·33 | " | 24 | " | 222· |
| " | 14 | " | 88·8 | " | 26 | " | 254·3 |
| " | 16 | " | 111·4 | " | 28 | " | 288·5 |
| " | 18 | " | 136·1 | " | 30 | " | 324·4 |

And, $7{\cdot}563^2$ feet $= 57{\cdot}2$. $5{\cdot}042^2 = 25{\cdot}4$. J.

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*Gas Generators.*

The November number of the *London, Edinburgh, and Dublin Philosophical Magazine* contains an account of a bungling imitation of Hare's self-regulating reservoir for hydrogen and other gases by a G. Gore, Esq.

Hare's apparatus, which is a modification of one invented by Gay-Lussac, is almost indispensable in any working laboratory and is remarkable for its neatness, simplicity, and cheapness. We have never seen it noticed in any European work on Chemistry, although when Döbereiner invented his hydrogen lamp, he showed his knowledge of it, by appropriating it without acknowledgment. Mr. Gore appears to have attempted the farther step of modifying it, as Clark did (in the same spirit) his blow-pipe; and the same result has been obtained, that is, a manifestly unfair apparatus. F.

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*The Magnetic Water Gauge.*

The *Civil Engineer and Architect's Journal* for November reproduces at some length and with evident marks of approbation the magnetic water gauge claimed as the invention of one M. Pinel, of Rouen. But in fact the instrument is the invention of Mr. Faber of this country, and will be found described in this *Journal* as early as March, 1851 (vol. xxii, 3rd series, p. 215).

The variation from Faber by M. Pinel renders the instrument less delicate and useful—for as it consists in producing a vertical rectilineal motion in the index, this can be of course only as great as that of the water level itself; whereas Mr. Faber's index rotates, and the arc described by its extremity will be greater as the index is longer. M. Pinel is also compelled to pass the rod carrying his magnet through a stuffing-box so as to avoid the action of the steam and foam on his magnet, causing it to stick to the sides of its tube. But in Mr. Faber's invention, which has been so largely practically in use for so many years, the motion is rotary and the magnet lies in the steam space itself.

The claims of Mr. Faber have been recognised by English Engineers at the meetings of their Institutes, why then should their magazines persist in endeavoring to ignore the claims of a prior inventor? F.

See our remarks upon the laudation of this same gauge by the Abbè Moigno, May, 1855, vol. xxix, 3d series, page 350.

For the Journal of the Franklin Institute.

*Strength of Materials:* Deduced from the latest experiments of Barlow, Buchanan, Fairbairn, Hodgkinson, Stephenson, Major Wade, U. S. Ordnance Corps, and others. By CHAS. H. HASWELL, Civil and Marine Engineer.

No. 3.

(Continued from page 391, vol. xl.)

*To ascertain the Transverse Strength of a Rectangular Bar or Beam.*

*When a Bar or Beam is Fixed at one End, and Loaded at the other.*

RULE.—Multiply the *Value* of the material in the preceding tables, or as ascertained, by the breadth, and square of the depth, in inches, and divide the product by the length in feet; the quotient is the result in pounds.

NOTE.—When the beam is loaded uniformly throughout its length, the result must be doubled.

EXAMPLE.—What are the weights each that a cast and a wrought iron bar, 2 inches square and projecting 30 inches in length, will bear without permanent injury?

The *values* for cast and wrought iron in this and the following calculations, are assumed to be 250 and 200.

*Hence,* $250 \times 2 \times 2^2 = 2000$, *which*, $\div 2{\cdot}5 = 800$ *lbs.*
$200 \times 2 \times 2^2 = 1600$, *which*, $\div 2{\cdot}5 = 640$ *lbs.*

OR, *If the Dimensions of a Bar or Beam be required to Support a Given Weight at its End.*

RULE.—Divide the product of the weight and the length in feet, by the *Value* of the material, and the quotient will give the product of the breadth and the square of the depth of the bar or beam.

EXAMPLE.—What is the depth of a wrought iron beam, 2 inches broad, necessary to support 640 lbs. suspended at 30 inches from the fixed end?

$\frac{640 \times 2{\cdot}5}{200} = 8$, *which*, $\div 2$ *ins. for the breadth*, $= 4$, and $\sqrt{4} = 2$ = *the depth required in inches.*

*When a Bar or Beam is Fixed at both Ends, and Loaded in the Middle.*

RULE.—Multiply the *Value* of the material in the preceding tables, or as ascertained, by six times the breadth, and the square of the depth, in inches, and divide the product by the length in feet, the quotient is the result in pounds.

NOTE.—When the beam is loaded uniformly throughout its length, the result must be doubled.

EXAMPLE.—What weight will a bar of cast iron, 2 inches square and 5 feet in length, support in the middle, without permanent injury?

$$250 \times \overline{2 \times 6} \times 2^2 = 12{,}000, \textit{ which, } \div 5 = 2400 \textit{ lbs.}$$

OR, *If the Dimensions of a Bar or Beam are required to Support a Given Weight in the Middle, between the Fixed Ends.*

RULE.—Divide the product of the weight and the length in feet, by six times the *Value* of the material, and the quotient will give the product of the breadth, and the square of the depth of the bar or beam.

EXAMPLE.—What dimensions will a cast iron bar, 5 feet in length, require to support without permanent injury, a stress of 2400 lbs.?

$\frac{2400 \times 5}{250 \times 6} = \frac{12000}{1500} = 8$, *which*, $\div 2$ *ins. for the assumed breadth*, $= 4$, and $\sqrt{4} = 2 =$ *the depth required in inches.*

*When the Breadth or Depth is required.*

Divide the product obtained by the preceding rules by the square of the depth, and the quotient is the breadth; or by the breadth, and the square root of the quotient is the depth.

ILLUSTRATION.—If 128 is the product, and the depth is 8:
*Then*, $128 \div 8^2 = 2$, *the breadth.*
*Also*, $128 \div 2 = \sqrt{64} = 8$, *the depth.*

*When the Weight is not in the Middle between the Ends.*

RULE.—Multiply the *Value* in the preceding table, or as ascertained, by three times the length in feet, and the breadth and square of the depth, in inches, and divide the product by twice the product of the distances of the weight, or stress from either end.

EXAMPLE.—What is the weight a cast iron bar, fixed at both ends, 2 inches square and 5 feet in length, will bear without permanent injury, 2 feet from one end?

$$\frac{250 \times 3 \times 5 \times 2 \times 2^2}{2 \times 2 \times 3} = \frac{30{,}000}{12} = 2500 \textit{ lbs.}$$

*When a Bar or Beam is Supported at both Ends, and Loaded in the Middle.*

RULE.—Multiply the *Value* of the material in the preceding tables, or as ascertained, by four times the breadth, and the square of the depth, in inches, and divide the product by the length in feet, the quotient is the result in pounds.

NOTE.—When the beam is loaded uniformly throughout its length, the result must be doubled.

EXAMPLE.—What weight will a cast iron bar, 5 feet between the supports, and 2 inches square, bear in the middle, without permanent injury?

$$250 \times 2 \times 4 \times 2^2 = 8000, \textit{ which, } \div 5 = 1600 \textit{ lbs.}$$

OR, *If the Dimensions be required to Support a Given Weight.*

RULE.—Divide the product of the weight and length in feet, by four times the *Value* of the material, and the quotient will give the product of the breadth, and the square of the depth of the bar or beam.

*When the Weight is not in the Middle between the Supports.*

RULE.—Multiply the *Value* of the material in the preceding tables,

or as ascertained, by the length in feet, and the breadth, and the square of the depth, in inches, and divide the product by the product of the distances of the weight, or stress from either support.

Example.—What weight will a cast iron bar, 2 inches square and 5 feet in length, support without permanent injury, at a distance of 2 feet from one end, or support?

$$\frac{250 \times 5 \times 2 \times 2^2}{2 \times (5 - 2)} = \frac{10\,000}{6} = 1666{\cdot}67 \text{ lbs.}$$

*To ascertain the Pressure upon the Ends or upon the Supports.*

Rule.—1. Divide the product of the weight and its distance from the nearest end or support, by the whole length, and the quotient will give the pressure upon the end or support furthest from the weight.

2. Divide the product of the weight and its distance from the furthest end, or support, by the whole length, and the quotient will give the pressure upon the end or support nearest the weight.

Example.—What is the pressure upon the supports in the case of the preceding example?

$$\frac{1666{\cdot}67 \times 2}{5} = 666{\cdot}67 \textit{ lbs. upon support furthest from the weight.}$$

$$\frac{1666{\cdot}67 \times 3}{5} = 1000 \textit{ lbs. upon support nearest to the weight.}$$

*When a Bar or Beam, Fixed or Supported at both Ends, bears two Weights at unequal Distances from the Ends.*

Let $m$ represent *distance of greatest weight from nearest end.*
$n$ " *distance of least weight* "
$W$ " *greatest weight.*
$w$ " *least weight.*
$L$ " *whole length.*
$l$ " *distance from least weight to furthest end.*
$l'$ " *distance of greatest weight from furthest end.*

*Then,* $$\frac{m \times W}{L} + \frac{l \times w}{L} = \textit{pressure at } w \textit{ end,}$$

*and,* $$\frac{n \times w}{L} + \frac{l' \times W}{L} = \textit{pressure at } W \textit{ end.}$$

*When a Bar or Beam is Fixed at one or both Ends, or Supported at both Ends, and the Weight increases as the distance from the free end, or from one of the supports, as the case may be.*

The effect of the weight is $\frac{16}{31}$ of that which would be produced if it was applied at the end or in the middle; *hence,* for all practical purposes it may be taken as double.

*When the Plane of the Bar or Beam projects obliquely Upwards or Downwards.*

*When Fixed at one End and Loaded at the other.*

Note.—When the weight is laid uniformly along its length, the result must be doubled.

RULE.—Multiply the *Value* of the material in the preceding tables, or as ascertained, by the breadth and square of the depth, in inches, and divide the product by the product of the length in feet and the cosine of the angle of elevation or depression.

EXAMPLE.—What is the weight an Oak beam, 5 feet in length, 3 inches square, and projecting upwards at an angle of 7° 15′, will bear without permanent injury?

$55 \times 3 \times 3^2 = 1485$, *which*, $\div \overline{5 \times \cos. 7°15'} = 1485 \div \overline{5 \times .99^2} = 299{\cdot}39$ lbs.

*To ascertain the Transverse Strength of Cylinders, Ellipses, &c., &c.*

*When a Cylinder, Rectangle (the diagonal being vertical), Hollow Cylinder, or Beams having sections of an Ellipse and Equilateral Triangle, are either Fixed at one End and Loaded, the Load applied in the Middle, or between the Supports.*

RULE.—Proceed in all cases as if for a rectangular beam, taking for the breadth and depth and *Value* of the material, as follows:—

| | | |
|---|---|---|
| Cylinder, | diameter$^3$ | $\times \cdot 6$ of *Value.* |
| Rectangle,* | side$^3$ | $\times \cdot 7$ " |
| Hollow Cylinder | (diam.$^3$— diam.$'^3$), | $\times \cdot 6$ " |
| Ellipse, transverse diam. vertical | conj. $\times$ transverse$^2$, | $\times \cdot 6$ " |

*Fixed at One or Both Ends.*

| | | | |
|---|---|---|---|
| Equilateral Triangle, | edge up, | breadth $\times$ depth$^2$, | $\times \cdot 2$ of *Value.* |
| do, | edge down, | " | $\times \cdot 34$ " |
| T Bar or Beam, | " | " | $\times \cdot 42$ " |

*Supported at Both Ends.*

| | | | |
|---|---|---|---|
| Equilateral Triangle, | edge up, | breadth $\times$ depth$^2$, | $\times \cdot 34$ of *Value.* |
| do, | edge down, | " | $\times \cdot 2$ " |
| ⊥ Bar or Beam, | edge up, | " | $\times \cdot 42$ " |

*To ascertain the Diameter of a Solid Cylinder to Support a Given Weight.*

*When Fixed at One End, and Loaded at the Other.*

RULE.—Multiply the weight to be supported, in pounds, by the length of the cylinder, in feet; divide the product by $\cdot 6$ of the *Value* of the material, and the cube root of the quotient will give the diameter.

NOTE.—When the cylinder is loaded uniformly throughout its length, the cube root of half the quotient will give the diameter.

EXAMPLE.—What should be the diameter of a cast iron cylindrical beam, 8 inches in length, to support 1500 lbs. without permanent injury?

8 inches is $\cdot 66$ feet. $\dfrac{15{,}000 \times \cdot 66}{\cdot 6 \times 250} = 66,$

and, $\sqrt[3]{66} = 4{\cdot}04$ inches.

* The strength of a Rectangle, the diagonal being vertical, compared to that of its circumscribing rectangle, when the direction of the strain is parallel to the side of it, is as $\cdot 245$ to 1.

*When Fixed at Both Ends, the Weight applied in the Middle.*

RULE.—Multiply the weight to be supported, in pounds, by the length of the cylinder in feet; divide the product by ·6 of the *Value* of the material, and the cube root of one-sixth of the quotient will give the diameter.

NOTE.—When the cylinder is loaded uniformly along its length, the cube root of half the quotient will give the diameter.

EXAMPLE.—What should be the diameter of a cast iron cylinder, 2 feet in length between the ends, to support 21,000 lbs. without permanent injury?

$$\frac{21{,}000 \times 2}{\cdot 6 \times 250} = 286, \quad \text{and} \quad \sqrt[3]{\frac{280}{6}} = 3{\cdot}59 \text{ inches.}$$

*When Supported at Both Ends, the Weight applied in the Middle.*

RULE.—Multiply the weight to be supported, in pounds, by the length of the cylinder between the supports, in feet; divide the product by ·6 of the *Value* of the material, and the cube root of one-fourth of the quotient will give the diameter.

NOTE.—When the cylinder is loaded uniformly along its length, the cube root of half the quotient will give the diameter.

EXAMPLE.—What should be the diameter of a cast iron cylinder, 2 feet between the supports, that will support 60,000 lbs. without permanent injury?

$$\frac{60{,}000 \times 2}{\cdot 6 \times 250} = 800, \quad \text{and} \quad \sqrt[3]{\frac{800}{4}} = 5{\cdot}85 \text{ inches.}$$

And what its diameter, if loaded uniformly along its length?

$$\frac{800 \div 2}{4} = 100, \quad \text{and} \quad \sqrt[3]{100} = 4{\cdot}64 \text{ inches.}$$

*To ascertain the Relative Value of Materials to resist a Transverse Strain.*

*Let* V *represent this value in a beam, bar, or cylinder, one foot in length, and one inch square, side, or in diameter;* W, *the weight;* l, *the length;* b, *the breadth;* d, *the depth;* m, *the distance of the weight from one end; and* n, *the distance of it from the other.*

NOTE.—In cylinders, for $b\,d^2$ put $d^3$.

1. *Fixed at one end.* Weight suspended from the other.

$$\frac{l\,W}{b\,d^2} = V.$$

2. *Fixed at both ends.* Weight suspended from the middle.

$$\frac{l\,W}{6\,b\,d^2} = V.$$

3. *Supported at both ends.* Weight suspended from the middle.

$$\frac{l\,W}{4\,b\,d^2} = V.$$

4. *Supported at both ends.* Weight suspended at any other point than the middle.

$$\frac{m\ n\ \text{W}}{l\ b\ d^2} = \text{V}.$$

5. *Fixed at both ends.* Weight suspended at any other point than the middle.

$$\frac{2\ m\ n\ \text{W}}{3\ l\ b\ d^2} = \text{V}.$$

From which formulæ, the weight that may be borne, or any of the dimensions, may be found by the following:

1. $$\frac{\text{V}\ b\ d^2}{l} = \text{W}\ .\ \frac{\text{V}\ b\ d^2}{\text{W}} = l\ .\ \frac{l\ \text{W}}{\text{V}\ d^2} = b\ \cdot\ \sqrt{\frac{l\ \text{W}}{b\ \text{V}}} = d.$$

In rectangular beams, &c., $b$ and $d = \sqrt[3]{\frac{l\ \text{W}}{\text{V}}}$.

2. $$\frac{6\ b\ d^2\ \text{V}}{l} = \text{W}\ .\ \frac{6\ b\ d^2\ \text{V}}{\text{W}} = l\ .\ \frac{l\ \text{W}}{6\ d^2\ \text{V}} = b\ .\ \sqrt{\frac{l\ \text{W}}{6\ b\ \text{V}}} = d.$$

In rectangular beams, &c., $b$ and $d = \sqrt[3]{\frac{l\ \text{W}}{6\ \text{V}}}$.

3. $$\frac{4\ b\ d^2\ \text{V}}{l} = \text{W}\ .\ \frac{4\ b\ d^2\ \text{V}}{\text{W}} = l\ .\ \frac{l\ \text{W}}{4\ d^2\ \text{V}} = b\ .\ \sqrt{\frac{l\ \text{W}}{4\ b\ \text{V}}} = d.$$

In rectangular beams, &c., $b$ and $d = \sqrt[3]{\frac{l\ \text{W}}{4\ \text{V}}}$.

4. $$\frac{l\ b\ d^2\ \text{V}}{m\ n} = \text{W}\ .\ \frac{m\ n\ \text{W}}{b\ d^2\ \text{V}} = l\ .\ \frac{m\ n\ \text{W}}{l\ d^2\ \text{V}} = b\ .\ \sqrt{\frac{m\ n\ \text{W}}{l\ b\ \text{V}}} = d.$$

In rectangular beams, &c., $b$ and $d = \sqrt[3]{\frac{m\ n\ \text{W}}{l\ \text{V}}}$.

5. $$\frac{3\ l\ b\ d^2\ \text{V}}{2\ m\ n} = \text{W}\ .\ \frac{2\ m\ n\ \text{W}}{3\ b\ d^2\ \text{V}} = l\ .\ \frac{2\ m\ n\ \text{W}}{3\ l\ d^2\ \text{V}} = b\ \cdot\ \sqrt{\frac{2\ m\ n\ \text{W}}{3\ l\ b\ \text{V}}} = d.$$

In rectangular beams, &c., $b$ and $d = \sqrt[3]{\frac{2\ m\ n\ \text{W}}{3\ l\ \text{V}}}$.

When the weight is uniformly distributed, the same formulæ will apply, W representing only half the required or given weight.

When the weight increases as the distance from the free end or from one of the supports, as the case may be, the same formulæ will apply, W representing $\frac{1}{1}\frac{6}{5}$ the required or given weight.

### Transverse Strength of Cast Iron.

As Cast iron resists crushing or compression with a greater force than extension, it follows that the flanch of a Girder or Beam which is subjected to a compressing strain, according as the girder or beam

is *supported at both ends* or *fixed at one end*, should be of less area than the other flanch, which is subjected to extension or tensile stress.

The resistance of cast iron to compression and extension, or crushing and tensile strains, is for American, as 4·6 to 1, and for English, as 5·3 to 1.*

The mean tensile strength of American cast iron, as determined by Major Wade for the U. S. Ordnance Department, is 31,829 lbs. per square inch of section; and the mean of English, as determined by E. Hodgkinson, Esq., for the Railway Commission, in 1849, is 16,330 lbs.

The ultimate extension of cast iron is the 500th part of its length.

The mean transverse strength of American cast iron, also determined by Major Wade, is 681 lbs. per square inch, suspended from a bar fixed at one end and loaded at the other; and the mean of English, as determined by Fairbairn, Barlow, and others, is 500 lbs.

The position of the *Neutral Axis* is at the centre of gravity of the section.

From the experiments of Mr. Hodgkinson, it was deduced that with flanched beams I, the area of the bottom flanch should be six times greater than that of the top flanch, and that the two flanches should be connected by a thin vertical arch, sufficiently rigid, however, to possess lateral strength.

The most effective outline of a cross section of the web is one tapering outwards, both upwards and downwards from the neutral axis, and meeting each flanch with a thickness corresponding to that of the flanch.

## Transverse Strength of Wrought Iron.

As Wrought iron resists crushing or compression with a greater force than extension, it follows that the flanch of a Girder or Beam, which is subjected to a crushing strain, according as the girder or beam is *supported at both ends*, or *fixed at one end*, should be of less area than the other flanch, which is subjected to extension or a tensile strain.

The resistance of wrought iron to compression or extension, or crushing and tensile strains, is for American as 1·5 to 1, and for English, as 1·2 to 1.

The mean tensile strength of American wrought iron, as determined by Professor Johnson, in 18—, is 55,900 lbs., and the mean of English, as determined by Capt. Brown, Barlow, Brunel, and Fairbairn, is 53,900 lbs.†

The ultimate extension of wrought iron is the 600th part of its length.

The resistance to flexure acting evenly over the surface, is nearly one-half the tensile resistance.

The position of the *Neutral Axis*, alike to that of cast iron, is at the centre of gravity of the section.

*The experiments of Mr. Hodgkinson on iron of low tensile strength, gives a mean of 6·595 to 1.

†The results, as given by Telford, included experiments upon Swedish iron, hence they are omitted in this summary.

(To be Continued.)

## *The Caloric Engine.*

[Proceedings of the Polytechnic Association of the American Institute, Oct. 31, 1860, from the Architects and Mechanics' Journal. Corrected by T. D. STETSON Esq.]

The President proposed three questions to be answered by those explaining the caloric engine: first, as to the burning out of the heaters; for if they are liable to be burned out frequently, it is an objection to its economical use, not only from the expense, but from the frequent interruptions in the working of the engine. The second, also in the form of an objection, relates to the small amount of force that could be accumulated. The air being heated as it is used, no provision can be made, as in the steam boiler, for a supply of work for a little time. The heating-up occurs at the moment, and is liable to disappointment upon the slightest accident or occasion of delay. The third and strongest objection relates to the small amount of power that is obtained. It is only changing one gas, not into another, but an expansion of the same gas; whereas in making steam, we expand a liquid instantly to 1700 times its bulk. In air engines, double the volume is all that is usually obtained. He would like to hear either some answer to these objections, or evidence that, in spite of these objections, the economy is such as to make the caloric engine valuable.

Mr. G. H. Babcock exhibited drawings of Wilcox's caloric engine, (an engine recently invented by S. Wilcox, Jr., of Westerly, R. I.,) and explained its construction and mode of operation. Although air engineering is younger than steam engineering, much attention has been paid to it, between 200 and 300 patents having been granted for air engines, or improvements upon air engines, in Great Britain alone, and thirty-five in the United States. These may all be classified in four grand divisions. In the first class may be placed all those engines in which a reservoir of expanded air is maintained as a reservoir of power, similar in effect to the steam boiler. The air is allowed to escape into an engine of proper character, and worked off like steam from a steam boiler. The second class includes all those which use the gaseous products of combustion within the engine. The power may be generated within the engine itself, or in a heater; this class will include the explosive engines. The third class includes the engines which use a certain quantity of air, which is alternately heated and cooled in opposite portions of the stroke; the difference in temperature in different parts of the stroke generating power in the engine. The Stirling engine belonged to this class. The fourth class includes all those engines which use atmospheric air, drawing their supply from the atmosphere at each stroke, and exhausting again into the atmosphere. This class will include the great experimental caloric ship of Ericsson, the small caloric engine of Ericsson, and also the Wilcox engine; it includes all the caloric engines now in successful use.

The President.—Please to state why these are the only ones in use.

Mr. Babcock.—I do not know that there is any good reason why there are not engines of the third class. The second class, in which

the gaseous products of combustion are used, have, in all cases so far, failed because of the excessive heat occasioned by combustion, and of the abrasion occasioned in the cylinder and other working parts by the solid products of combustion. And for the first class I know no positive reason.

The President.—Are there not difficulties connected with accumulating a reserve of power?

Mr. Babcock.—There are practical difficulties in condensing the air. Some power is lost in the condensation, owing to the development of heat in the compression, which is lost, in a great measure. Of all the experiments which have been made, there seem to have been but three which have been practically successful: the Stirling engine, the Ericsson engine, and the Wilcox engine. The Stirling engine, after the death of the inventor, having been disused, in consequence of the jealousy of steam engineers, the Ericsson and Wilcox engines are the only ones now in practical operation. Of the Ericsson engine, several hundreds have been constructed, and are now in operation.

The President.—How small a power is used?

Mr. Babcock.—One-man power, which is about a fifth of a horse power, is considered quite a respectable power. To drive an ordinary sewing machine requires about one-sixtieth of a horse power. One of the small air engines would drive quite a number of these machines. The Ericsson engines run up to two horse power in some cases; perhaps more for the double engines. The Wilcox engine has not been fully tested. There is an 18-in. Wilcox engine estimated by the owners as $3\frac{1}{2}$ horse power, in a large bakery in Pawtucket. This is probably above its actual power. It is stated that it does not average over 60 lbs. of coal in 12 hours, and has run with 46 lbs.

The Wilcox engine has two upright cylinders connected at their lower ends next to the fire. One of the cylinders is used as a working cylinder and is single-acting, open at the upper end. The other, termed a changing cylinder, is double-acting, but the piston is always in equilibrium, so that all the resistance it occasions is due to the friction of the air and the friction of the parts. The pistons are connected with cranks upon the main shaft, which are placed nearly at right angles. This produces a motion nearly corresponding to the theory, which would be that each piston should make its entire stroke while the other is at its dead-point. Between these two cylinders is the economizer, a chamber so filled with thin metal plates as to allow the free passage of air, and connected with both cylinders at the bottom. It is intended to absorb as much as possible of the heat of the air passed upwards through it, and to return it to the next downward current. It has been contended that the economizer is of no theoretic value. Practice seems to prove its value in this engine at least, for the engine has been found to run light, other circumstances being equal, twice the number of revolutions with the economizer that it will run without it. It is also found that the engine will keep running for half an hour or more, by simply passing the same air back and forth; the valve being so set as not to take in any fresh air. Above the econo-

mizer is the valve chest, which contains a single rolling three-way valve, with the three-fold office of induction, eduction, and equilibrium valve. The heat is applied at the bottom, not by direct radiation, but by passing the products of combustion under and around the cylinders. In consequence of cutting off the direct radiation, the heaters are expected to last longer. The heaters are prevented from being overheated by automatic action; the vapor of mercury, which is formed at 600°, operating means which shut off the heat from the cylinders.

The President inquired what was the durability of the heaters.

Mr. Babcock stated that the engines had only been in operation for six months, so that there were no means of knowing. The Stirling engine heaters lasted for two years, and these ought to last as long.

A gentleman inquired how it was lubricated.

Mr. Babcock explained how the oil was prevented from being burned. A perforated cover was placed on the open end of the working cylinder, the perforations being slightly inclined, so that at each descent of the piston, the cool air impinged upon the metal in numerous streams, to be driven out again on its ascent, thus conveying away the heat. He stated that there was no packing in the piston in the inclosed cylinder, there being always nearly an equilibrium in that cylinder.

Mr. Churchill inquired what were the cubical contents of the economizer.

Mr. Babcock stated that it was about one-fourth the size of one of the cylinders.

A gentleman inquired what was the economy of this engine.

Mr. Babcock said that if the Pawtucket engine had a two horse power, it burned $2\frac{1}{2}$ lbs. of coal per hour to the horse power; which was about one-third of what any steam engine of the same power would require. *Large* steam engines sometimes run with as little coal in proportion to their power.

Mr. Babcock explained, by the aid of several large and finely executed diagrams, the motions of the several parts, and the pressure under the working piston at each point in the revolution, which attracted much attention. He explained that the pressure was derived from theory, and would be somewhat less in practice; but would not probably vary more than 25 or 30 per cent. from that indicated upon the diagrams. The maximum pressure by the diagrams was 22 pounds above the atmosphere; the pressure being about two-thirds that amount at the commencement, increasing to near one-quarter stroke, and thence declining till the exhaust valve opens.

The President.—Inasmuch as all that you do to the air is to double its volume, while in raising steam you increase the volume 1700 times, wherein does the economy lie?

Mr. Babcock.—In the greater facility of heating air, and its small amount of specific heat, which is only one-fourth of that of water. There is also much heat lost in raising water to the boiling point.

The President.—Is this engine free from danger?

Mr. Babcock.—Perfectly free from all danger.

Mr. C. A. Seely expressed his surprise that the peculiar circumstance of the difference of the specific heat of air and water had not

been mentioned before. The same heat will heat a pound of air four times as high as a pound of water.

Mr. F. Dibben said the Wilcox engine was very similar to the Ericsson engine, but in comparing the two, and estimating the contents of the working cylinder, it would be necessary to take the contents of both cylinders in the Wilcox engine, since the two correspond to the one in Ericsson's. He failed to appreciate the difference between Mr. Wilcox's engine and the engines in the caloric ship *Ericsson*, in 1853.

Mr. T. D. Stetson explained one of the great points in which the Wilcox engine differed radically from those in the *Ericsson*. In that ship, the supply of air was forced in by pumping it through large force pumps, against the pressure which obtained within. In the Wilcox engine, there is a period while the working piston is descending, where the whole interior of the engine is in free communication with the external atmosphere. During that period, the changing piston descends and inhales a full charge of cold air above it, precisely as the air enters an accordeon when it is expanded. The descent of the changing piston occasions no resistance, because there is then no pressure against the under side of that piston. The moment it is thus inhaled, the induction port closes, and the dense cold air is subsequently transferred by the rising of the changing piston into the hot part of the engine, when, by its expansion, the working piston is forced up, and power is developed. The rising of the changing piston occasions no resistance, because while it rises the same pressure obtains on its under as on its upper side, whatever that may be. The two sides are in free communication through the openings in the economizer. As the changing piston rises and compels the air above it to pass down through the economizer into the hot part of the engine, the pressure rises in consequence of the heat received by the air; but it is felt equally on the upper and under side of the changing piston, and is only sensible on the working piston, which latter receives the pressure on its under side. The upper end of the working cylinder it always opens to the atmosphere. The question of most interest, Mr. Stetson believed, was not the difference between this and the previous varieties of air engines, but whether either or any had practically solved the problem presented, and was really a successful and important machine. He believed that both Ericsson's and Wilcox's engines were fairly entitled to be thus considered. Between five and six hundred of the Ericsson engines, and a small number—about a dozen—of the Wilcox engines are now in daily and successful use.

Mr. Roosevelt inquired if the caloric yacht was not lying up. Was she a success? He had seen a boat driven by a "six horse power" caloric engine, which could be driven as well by two men with oars. He could stop any caloric engine by pressure upon the periphery of the fly wheel with an axe.

Mr. Stetson said the engine was, to his certain knowledge, doing efficiently and satisfactorily the work for which it was purchased, in a great number of instances, without involving any expense for attendance, or increasing the rate of insurance. He confessed that Ericsson's engines are very much over-rated in their power. He had tested

one carefully by the friction-brake. It was an 18-inch engine, employed in driving printing-presses at Dodge & Grattan's, in this city. It was rated by some at four-horse power. Mr. Stetson found that, when diligently fired, it performed with exactly two-thirds of one horse power. But the extravagance of some estimates should not lead us to under-rate its actual performance. The caloric engine, both of Ericsson and Wilcox, was a success. It was difficult to compare strictly with steam engines. The performance of an engine depends upon many conditions; so that a steam engine of "two-horse power" may do the work of only one man, or of six or eight horses. The expense and trouble of replacing the heaters is very small. The Ericsson heaters are much more exposed than the Wilcox heaters; but even in the Ericsson engine the most exposed parts endured a year or more with moderately hard firing, and were replaced at an expense of only $15. The great economy of the caloric engine, mainly arose from the ease with which it may be kept in operation without a professional engineer.

Mr. J. K. Fisher remarked that some steam engines were worked at less than atmospheric pressure; so that the safety of those steam engines is as great as that of the caloric engines.

Lieut. Bartlett thought there should be no contest between steam and air engines. The steam engine has proved itself to the world. But there is a great want of an economical very small power, which requires little skill or attention. He had not hesitated to say to Mr. Ericsson that his success and his fame would rest upon the fact that he had supplied a little power, which was a very great necessity in the community.

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For the Journal of the Franklin Institute.

## *Steamboat Speed.*

The steamboat *Daniel Drew*, the details of which I furnished for your July number, page 47, has lately made a run from New York to Albany, 150 miles, in the unprecedented time of 6 hours and 50 minutes, tide favorable, but wind ahead: her time to Hudson, 125 miles, was 5 hours and 5 minutes, which is equal to a speed of 24·6 miles per hour. From this is to be deducted the velocity of the tide, a full allowance for which is 2·3 miles, leaving 22·3 miles per hour as the actual speed of this boat through the water, with an adverse wind.

The time to Hudson is selected from the circumstance, that above that point, the river is too shallow to admit of very high speeds.

The times of previous quick runs are as follows:—

| | | | | | |
|---|---|---|---|---|---|
| North America, | 1826, | 10 | hours, | 20 | minutes. |
| do. lengthened, | 1832, | 9 | " | 21 | " |
| Albany, | 1840, | 8 | " | 27 | " |
| Troy, | 1841, | 8 | " | 10 | " |
| Alida, | 1849, | 7 | " | 45 | " |
| New World, | 1851, | 7 | " | 43 | " |
| Francis Skiddy, | 1852, | 7 | " | 30 | " |
| Armenia, | 1860, | 7 | " | 42 | " |

C. H. H.

*Description of Carlsund's Drain Valve, with a suggested Improvement on the same.* By John W. Nystrom.

A great deal of difficulty is frequently experienced by water coming into the cylinder in steam engines. The principal cause of this inconvenience arises from priming in the steam boilers, by which the water comes into a violent motion, and fills the steam room in the form of foam, which finally is carried along with the steam into the cylinders, and when in too great a quantity, it partly resumes the water form in the cylinder, and does not go out with the exhaust steam until the piston approaches the end of the return stroke, when the slide valve has closed the eduction passage; the inclosed water then causes a violent blow b·tween the piston and the cylinder head, which infallibly produces an undue strain in the machinery. Sometimes this inconvenience does not end in straining or breaking the crank pin, but the incompressibility of the water against the momentum of the machinery assists directly in demolishing the whole engine.

To overcome this difficulty, arrangements must be made to drain the cylinder, for which purpose cocks are most frequently used in high pressure engines, to be opened by hand when notice is given by the water inside.

This notice is first given gently by noise in the cylinder, but according to the rate of priming, within a few strokes the shocks may become so strong as to break the cylinder bottoms, if the engineer is not attentive in opening the cocks. Condensing engines are frequently supplied with safety valves on the cylinder, loaded a little more than the steam pressure; these valves are called "escape valves," and generally loaded with a spring, so that when the space between the piston and the cylinder head is full of water, the piston forces it out through the escape valve. This is found to work very well, and it is self-operating, but in particular cases, to be described hereafter, the arrangement adopted by Captain Carlsund is by far preferable, as it drains the cylinder completely at every stroke, without an undue strain in the machinery.

In some cases the escape valves do not fully answer the purpose; for instance, in the upright trunk propeller engines, adopted lately in the Russian Navy, the water enters from the condenser and half fills the cylinders, the escape valves will not operate, and it is very difficult to start the engines.

Fig. 1 represents a horizontal steam cylinder, with its piston P moving in the direction of the arrow—at the end of the stroke the water will occupy part of the clearance between the piston and the cylinder head, until the steam enters and forces the water out through the valve *a* and the pipe *b* into the reservoir *c*, which latter contains a float *d* fixed on a tube *e e*, movable up and down, and guided in boxes as shown by the drawing. The tube *e e* has a number of holes in its lower end, covered by the box; when there is water enough in the reservoir *c* to lift the float *d*, with the tube *e e*, the small holes will enter the reservoir, through which the water is forced out by the steam, and thus the

cylinder is drained at every stroke of the piston. The reservoir *c* is always full with water and steam, with nearly the same pressure as that in the cylinder; no steam is lost except what is condensed in the reservoir and pipes, by radiation of heat. The tube *e e* is ground into the boxes so as to be steam-tight, but can still move freely up and down, as regulated by the water displacement of the float. By this arrangement, no water can be collected in the cylinder, except what is formed during one stroke of the piston, and no shocks or breaking of machinery need be feared.

Fig. 1.

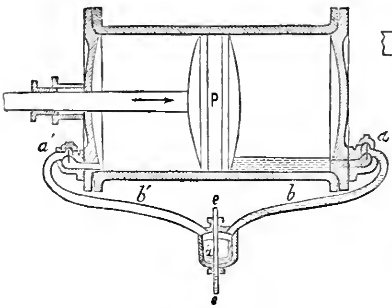
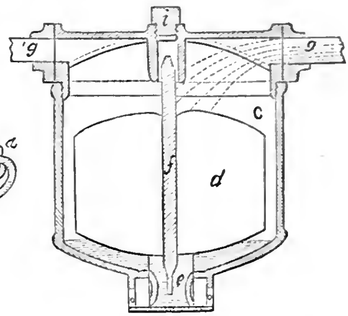



Fig. 2.




The tube *e e*, guided in the boxes, forms an equilibrium valve,—if the float *d* was connected with a common valve at the lower end, the steam pressure would be too great for the displacement to lift it up, therefore, some kind of equilibrium valve is necessary. Captain Carlsund has named the valve boxes *a a*, "Separatuers," and the reservoir *c*, "Floatuer." This arrangement of drain valves seems to be of great importance in marine engines, particularly when the steam boilers are subject to priming. However good the principle of an invention or arrangement may be, a slight defect in the details will most frequently damage the whole;—in this case, I beg to remark that the efficiency of the operation depends on the quality of the workmanship in grinding the tube *e e* in the boxes. If it is ground too loose, steam will leak out; if too tight, it will not operate well, and a slight difference in the expansion of the tube and boxes may cause its operation to be deficient. This consideration has led me to suggest an improvement on Captain Carlsund's drain valves,—the separators *a a*, the pipes *b b*, and the principle of operation remaining the same as described, only the floatuer *c*, I would suggest to make as represented by Fig. 2.

The improvement consists principally in the equilibrium valve *e*, Fig. 2, resting on the bottom of the box *h*. The valve *e* is connected to the float *d* by four wings cast in one piece with the spindle *f*. The operation of the valve is readily understood by the drawing, the steam and water entering the reservoir *c*, alternately through the pipes *g g*. When the float *d* lifts the valve *e*, the water is forced out by the steam through the holes *o o*, the valve is guided by the four wings, also by the spindle *f*, at the top. The screw *i* is taken out when the valve is

to be ground in, for which purpose the top of the spindle is made square. The lower part of the valve *e*, to be turned into a sharp edge of the same diameter as the upper part, which will make the valve perfectly equilibrium, and the steam pressure has no effect to open or close the same, but is under the sole control of the displacement of the float *d*. When there is no water in the reservoir, the weight of the float will keep the valve tight, but it need not be so perfectly tight, because there will always be some water which at any rate is to be let out.

The floatuer *c* need not be placed under the cylinder as represented by Fig. 1; it can be placed on the side, or any where in the engine room.

A "drain valve" constructed on this plan will fully answer the desired purpose; it will drain the cylinder at every stroke of the piston, and there is no danger of any thing getting out of order.

It is of great importance to have this drain valve introduced in the corvette, where the steam boilers are so much subject to priming. A great deal of inconvenience has been experienced in the corvette by water coming into the cylinders.

The drain valve can also be applied to vertical cylinders.

It will be perceived, that when water primes into the cylinder in the down stroke, it must remain on the top of the flat piston until it returns and approaches the cylinder head, where it will strike with more or less violence, according to the quantity of water therein, the other engine being then on about half stroke, and has the greatest power to force the water out through the escape valve, which being loaded with, say 25 lbs. per square inch, will be a resistance on the piston of about 52 tons; but the incompressibility of the water striking suddenly between the two flat surfaces will exert a much greater force, and cause an undue strain in the machinery. The water which may prime into the cylinder under the piston will mostly be carried out with the exhaust steam, unless the quantity be very large, then the case will be the same as at the top.

In all those upright trunk engines there is another circumstance which admits water coming into the cylinders, namely, the eduction passage being placed in such position that water may pass from the condenser. It has therefore been proposed to put a copper plate into the condenser to prevent the water from entering the cylinder. The condenser is about 7 feet square inside, and the eduction passage is near to the starboard side; in a hard sea, and the ship leaning to the starboard, the water rolling in the condenser, it will be difficult to keep it out of the cylinder without the plate. It has been found in the *Wiborg* engines that the escape valves are not sufficient for draining the cylinders, for, when starting the engines, the cylinder may be half full of water, the steam pressure will not be sufficient to force the water out through the escape valves; therefore, it has been found necessary to place drain pipes from the bottom of the cylinders connected with stop cocks, to be operated by hand, but even by this, the cylinders cannot be well drained, because the drain pipes must be led upwards to where there is a place for the cock.

On the *Rattvisan* it is intended to put stop cocks, by which the cylinders can be drained only partially, and a body of water will still remain on the bottom for the piston to plunge into.

It has been proposed to the Technical Committee to apply the drain valves herein described to the upright trunk propeller engines, and the cylinders would be perfectly drained at every stroke, self-operating, and no dependence required on the engineer for the same. The drain valve would not operate so well on top, because the piston is so flat, but in all cases it would do better than the escape valve or stop cock, if properly arranged.—*Artizan, Oct.*, 1860.

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### *Tensile Strength of Iron increased by Rolling.*

There are some inventions which address themselves to our notice with much elaborate comparison of results between old and new methods of effecting the same object, and there are others which, from their very completeness and self-containedness (to coin a word), admit of scarcely more than the simple announcement of the fact of their discovery. The invention of James Watt's separate condenser might have been given to the world in half a dozen lines, whilst as many pages are usually dedicated to the introduction of a new brickmaking machine. We feel it necessary to premise thus much, because we wish to draw the attention of our readers to a fact which will be new to all of them (with the exception of a very limited circle), and which places us under the disadvantage above alluded to, of giving us no chance of making a long article about it. The fact, then, is simply this:—

Given, a bar of common malleable iron: it is possible, by a purely mechanical process, and without the aid of heat, to increase the tensile strength of that bar 50 per cent. "On what principle?" it will be asked. On the same principle that wire is stronger per square inch of section than the bar from which it was originally drawn. To Mr. Lauth, an American engineer, is due the merit of making this particular egg stand on end, and his process is, as will be seen, of the simplest. Bars of common merchant iron are passed cold between grooved rollers, until the requisite degree of compression is attained. We saw, at the works in Manchester, a bar, $2\frac{1}{8}$ ins. diameter, and 15 ft. long, rolled down to 2 ins. in ten minutes—(with practice, this time could be reduced one-half). This $\frac{1}{8}$-in. is not lost—as in turning a shaft in a lathe—as the bar is lengthened about $1\frac{1}{2}$ ins. to the foot. The bar came out quite polished, and parallel enough for shafting, but not quite straight. It was straightened by hand by two men in half an hour, and might be done by machinery in a few minutes. According to Mr. Fairbairn, "the effect of the consolidation was to increase the strength of the bar in the ratio of 10 to 15," in the experiments made by him. We think we have said enough to give all our readers a motive for wishing to hear of this invention being made accessible to the public.—*London Engineer, No.* 247.

For the Journal of the Franklin Institute.

## *Particulars of the Steamer Pembroke.*

Hull and machinery by Atlantic Works, Boston, Mass. Owners, Wm. E. Coffin & Co. Intended service, from Boston to Pembroke.

Hull.—Length on deck, 110 ft. Do. at load line, 107 ft. Breadth of beam (molded), 24 ft. 6 ins. Depth of hold, 9 ft. Do. to spar deck, 9 ft. Frames—apart at centres, 24 and 30 ins.; ˥, depth, 3·5 ins.; width of web, $\frac{3}{8}$-in.; width of flanches, 2·5 ins. 10 strakes of plates from keel to gunwale; thickness of plates, $\frac{1}{4}$ to $\frac{3}{8}$-in. Cross Floors, |, $\frac{1}{4}$ by 12 ins., single riveted. One independent steam, fire, and bilge pump. Two bulkheads. Length of engine room, 30·3 × 7·5 ft. Draft, aft, 9 ft. 3 ins. Tonnage, hull and engine room, 215. Area of immersed section at load draft of 9 ft. 3 ins., 146 sq. feet. Masts, two.—Rig, schooner.

Engine.—Vertical beam. Diameter of cylinder, 26 inches. Length of stroke, 3 feet. Maximum pressure of steam, 30 lbs. Cut-off, variable. Maximum revolutions at above pressure, 60. Weight of engines, 31,078 lbs.

Boiler.—One—Tubular return. Length of boiler, 14 ft. Breadth do., 6 ft. 6 ins. Weight do., without water, 19,593 lbs. Number of furnaces, two. Length of grate bars, 5 ft. 6 ins. Number of tubes, above, 72; flues, below, 2. Internal diameter of tubes, above, 4 ins.; flues, below, 1 ft. 8 ins. Length of tubes, above, 9 ft. 2 ins.; flues, below, 5 ft. 8 ins. Heating surface, 1329 sq. ft. Diameter of smoke pipe, 2 ft. 8 ins. Height do., 32 feet.

Propellers.—Diameter of screw, 8 feet. Length do., 2 ft. 6 ins. Pitch do., 17 to 20 ft. Number of blades, three.

Date of trial, October, 1860. C. H. H.

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For the Journal of the Franklin Institute.

## *Particulars of the Steamer General Flores.*

Hull built by Kirkman & Co. Machinery by Pusey, Jones & Co., Wilmington, Del. Intended service, Coast of Callao.

Hull.—Length on deck, from fore part of stem to after part of stern post, above the spar deck, 109 feet. Do. at load line, 102 feet. Breadth of beam at midship section, 19 ft. 6 ins. Depth of hold to spar deck, 8 ft. 6 ins. Floor timber at throats—molded, 10 ins., sided, 6 ins.—apart at centres, 22 inches. Length of engine and boiler space, 10 ft. 5 ins. Draft of water at load line, 8 ft. 6 ins. Do., below pressure and revolutions, 7 ft. 6 ins. Tonnage, custom house, 170. Area of immersed section at load line of 8 ft. 5 ins., 135 sq. ft. Displacement at load line, 295 tons. Masts and rig, fore-topsail schooner.

Engine.—Vertical condensing. Diameter of cylinder, 24 inches. Length of stroke, 2 ft. 4 ins. Maximum pressure of steam, 25 lbs. Cut-off, 6 to 18 ins. Maximum revolutions per minute, 75. Weight of engine, 30,300 lbs.

Boiler.—One—Horizontal tubular Length of boiler, 19 ft. 2 ins. Breadth do., 6 ft. Height do., exclusive of steam chimney, 5 ft. Number of furnace, one. Breadth do., 4 ft. 11$\frac{1}{2}$ ins. Length of grate bars, 4 ft. 6 ins. Number of tubes, 57 of 3·5 ins.; 8 of 3 ins. Length do., 9 ft. Heating surface (fire and flues), 696 sq. ft. Grate sur-

face, 22·5 sq. ft. Diameter of smoke pipe, 2 ft. 4 ins. Height do., 20 ft. Draft, natural. Consumption of coal per hour, 290 lbs.

Propellers.—Diameter of screw, 7 ft. 6 ins. Pitch do., 14 feet. Number of blades, four.

*Remarks.*—Poop cabin. C. H. H.

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For the Journal of the Franklin Institute.

## *Particulars of the Steam Towboats Resolute and Reliance.*

Hull built by B. C. Terry, N. J. Machinery by Cobb & Fields, Jersey City, N. J. Owner, Capt. Albert DeGroot. Intended service, New York Harbor.

Hull.—Length on deck, 93 ft. Do. at load line, 93 ft. Breadth of beam, 16 ft. Depth of hold, to spar deck, 7 ft. 6 ins. Frames—molded, 8 ins., sided, 5 ins —apart at centres, 12 ins. Keel, 12 ins. Draft, forward, 5 feet, aft, 8 feet. Tonnage, 100. Area of immersed section at load draft of 8 feet, 65 sq. feet. Speed in miles in 61 minutes, with tide, 17·5, against tide, 12·5.

Engines.—Vertical direct. Diameter of cylinder, 17 ins. Length of stroke, 17 ins. Maximum pressure of steam, 100 lbs.; average pressure, 75 lbs. Cut-off, ½ stroke. Average revolutions at above pressure, 95. Weight of engines, 20,160 lbs.

Boiler.—One—Return tubular. Length of boiler, 15 feet. Breadth do., 6 ft. 8 ins. Height do., exclusive of steam chimney, 8 feet. Weight do., without water, 18,000 lbs., with water, 29,180 lbs. Number of furnaces, two. Breadth do., 3 ft. 4 ins. Length of grate bars, 6 ft. 8 ins. Number of tubes, above, 58, flues below, 6. Internal diameter of tubes, above, 4 ins; flues, below, 2 of 10 ins., 4 of 6 ins. Length of tubes, above, 10 ft. 4 ins; flues, below, 6 ft. 10 ins. Grate surface, 48 sq. ft. Heating surface, 2500 sq. ft. Diameter of smoke pipe, 3 ft. 2 ins. Height do., 12 ft. Consumption of coal per hour, ¼ ton.

Propeller.—Diameter of screw, 7 feet 8 inches. Length do., 5 ft. 6 ins. Pitch do., 14 ft. Number of blades, four.

Date of trial, September, 1860. C. H. H.

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For the Journal of the Franklin Institute.

## *Particulars of the Steam Towboat A. T. Morris.*

Machinery by Cobb & Fields, Jersey City, N. J. Intended service, New York Harbor.

Hull.—Length on deck, 93 ft. 6 ins. Do. at load line, 93 ft. Breadth of beam, 16 ft. Depth of hold to spar deck, 7 ft. 6 ins. Frames—molded, 8 ins., sided, 5 ins.—apart from centres, 12 ins. Keel, depth, 12 ins. One independent steam, fire, and bilge pump. Draft, forward, 5 ft., aft, 8 ft. Tonnage, 101. Area of immersed section at load draft of 8 ft., 65 sq. ft.

Engines.—Oscillating. Diameter of cylinders, 17 inches. Length of stroke, 17 ins. Maximum pressure of steam, 100 lbs.; average of steam, 75 lbs. Cut-off, ½ stroke. Maximum revolutions at above pressure, 95. Weight of engines, 19,500 lbs.

Boiler.—One—Return tubular. Length of boiler, 15 ft. Breadth do., 6 ft. 8 ins. Height do., exclusive of steam chimney, 8 ft. Weight do., without water, 18,000 lbs., with water, 29,000 lbs. Number of furnaces, two. Breadth do., 3 ft. 4 ins. Length

of grate bars, 6 ft 8 ins. Number of tubes, above, 58; flues, below, 6. Internal diameter of tubes, above, 4 ins.; flues, below, 2 of 10 ins., 4 of 6 ins. Length of tubes, above, 10 ft. 4 ins.; flues, below, 6 ft. 10 ins. Grate surface, 48 sq ft. Heating surface, 2500 sq. ft. Diameter of smoke pipe, 3 ft. 2 ins. Height do., 12 ft. Consumption of fuel per hour, ¼ ton.

PROPELLERS.—Diameter of screw, 7 ft. 8 ins. Length do., 5 ft. 6 ins. Pitch of do., 14 ft. Number of blades, four.

Date of trial, October, 1860. C. H. H.

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| Blind Hinges, | E. R. Shepard, | Scranton, | Penna. | 2 |
| Blind Slat Machine, | H. B. Smith, | Lowell, | Mass. | 16 |
| Boot and Shoe Heels,—Cutting | E T. Green, | Stoneham, | " | 9 |
| ———,—Dressing | Stuart & Corson, | Marblehead, | " | 23 |
| ——— Soles,—Cutting | C. H. Griffin, | Lynn, | " | 23 |
| —— Crimping Machine, | Philander Shaw, | Abington, | " | 23 |
| Boots and Shoes, | S. F. Dexter, | Paris, | N. Y. | 16 |
| ——— | Port & Surgi, | New Orleans, | La. | 16 |
| ———,—Heel for | W. H. Peckham, | Hoboken, | N. J. | 30 |
| ———,—Gaiter | C. K. Bradford, | Lynn, | Mass. | 2 |
| ———,—Tools for Trimming | L. C. Rogers, | Danvers, | " | 16 |
| Bracelets,—Manufacture of | George Sanford, | Providence, | R. I. | 2 |
| Brackets,—Roof | Amos Jones, | Lebanon, | N. H. | 9 |
| Brick Machines, | John Parsons, | Cleveland, | Ohio, | 30 |
| —— Moulding Machines, | Hutchison & Brandberry, | C. Gerardeau, | Mo. | 16 |
| Bridle Bits.—Attachment for | J. D. Tracy, | Springfield, | Mass. | 23 |
| Brush Machine, | John Ruegg, | St. Louis, | Mo. | 9 |
| Bucket,—Collapsible | C. W. Curtis, | New Haven, | Conn. | 23 |
| Calculi.—Removing | Wm. A. Dudley, | Petersburg, | Va. | 23 |
| Canal Locks, &c.,—Gates of | Hurlburt & Thompson, | Port Byron, | N. Y. | 9 |

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| Cane Juice,—Evaporating | Richard Wright, . | London, | Engl'd, | 16 |
| Canes, &c.,— Handles for | Harvey & Ford, | Philadelphia, | Penna. | 2 |
| Cannon Balls.—Cast. Packing on | Lewis Evans, . | Morgantown, | Va. | 30 |
| Cans, Sealing . | H. Y. Wildey, . | Philadelphia, | Penna. | 16 |
| Carriage Jack, . | J. J. Pike, . | Chelsea, | Mass. | 9 |
| Cars,—Light for . | Robert Cathcart, | Baltimore, | Md. | 9 |
| Chimney Tops, . | John Pettingell, . | Lowell, | Mass. | 9 |
| Chloride of Lead,—Manufac. of | F. F Myer, . | City of | N. Y. | 23 |
| Churn, . | J. W. Kellberg, . | Pittsburgh, | Penna. | 16 |
| ——— . | W. W. Reid, . | Rochester, | N. Y. | 16 |
| ——— Dashers,—Blades of | S. T Lamb, . | N. Washington, | Ind. | 16 |
| ——————— . | J J. Watson, . | Buffalo, | N. Y. | 16 |
| Clothes Dryer, . | Elliot Dickerman, . | Richmond, | Vt. | 30 |
| —————— . | Charles Robinson, | Cambridgeport, | Mass | 2 |
| —————— . | Josee Johnson, . | City of | N Y. | 30 |
| ——— Squeezers, | Francis Arnold, . | Middle Haddam, | Conn. | 23 |
| Coffins,—Glass . | G. W. Scollay, . | St. Louis, | Mo. | 2 |
| ———.—Wooden | Frederick Brubach, | Lancaster, | Penna. | 9 |
| Copying Letters, . | A. L. Adams, . | Philadelphia, | " | 9 |
| Corn Husks,—Stemming | D. M. Melford, . | Jeffersonville, | Ind. | 2 |
| —— Planters, . | J. W Harbin, . | Delaware Sta. | " | 16 |
| —— Shellers, . | G W. Hathaway, | Tioga, | Penna. | 16 |
| Cotton Cleaners, . | Wm H. Johnson, . | Richmond, | Ark. | 2 |
| ——————— . | J. W. Thorne, . | Courtland, | Ala. | 16 |
| Couplings,—Car . | Adam Oot, . | Minetto, | N. Y. | 23 |
| ———,—Hose . | C. F. Spencer, . | Rochester, | " | 2 |
| ———,—Socket . | E P. Gleason, . | Providence, | R. I. | 16 |
| Cows,—Stabling . | Patrick Burke, . | Helena, | N. Y. | 9 |
| Crane,—Portable, . | Snyder & Smith, . | Hawley, | Penna. | 9 |
| Culinary Apparatus, | Israel Forman, . | Grafton, | Va. | 2 |
| Cultivators, . | N. C. Carter, . | Union City, | Ind. | 9 |
| ————— . | Cyrus Debolt, . | Ottawa, | Ill. | 9 |
| ————— . | Wm. May, . | Winchester, | Ohio, | 16 |
| Curtain,—Window | Butterfield & Bowker, | Boston, | Mass. | 16 |
| ——— Fixture,—Window | N. H. McLean, . | U. S. A. | | 2 |
| Diaper Pins, . | H. S. Lesher, . | Brooklyn, | N. Y. | 2 |
| Door Spring, . | Boyd & Belford, . | Philadelphia, | Penna. | 16 |
| ————— . | R. B. Donaldson, | Washington, | D. C. | 30 |
| Dovetailing Machines, . | Bain & Brown, . | Richmond, | Ind. | 16 |
| Drying Chambers, | J. E. Tourné . | New Orleans, | La. | 16 |
| Egg-beater, . | Uriah Baker, . | Brooklyn, | N. Y. | 23 |
| Electro-magnetic Helix, | Maurice Vergnes, | City of | " | 2 |
| Emery Wheels, . | J. D. Alvord, . | Bridgeport, | Conn. | 2 |
| Engines,—Caloric | A. A Henderson, | Portsmouth, | N. H. | 9 |
| ———,—Electro-magnetic | Maurice Vergnes, . | City of | N. Y. | 2 |
| ———,—Oscillating | C. R. Otis, . | Yonkers, | " | 2 |
| —————————— . | E. G. Otis, . | " | " | 2 |
| ———,—Rotary | K. and T. Cox, . | City of | " | 16 |
| ——————— . | Wm. Humphreys, Jr., | Cold Spring, | " | 2 |
| ——————— . | Frederick Kettler, | Milwaukie, | Wis. | 23 |
| Envelope Ruler, . | Arthur de Witzleben, . | Washington, | D. C. | 23 |
| Evaporating Pans, | H. O. Ames, . | New Orleans, | La. | 16 |
| Faucets,—Measuring . | Gilbert Hubbard, . | Montville, | Mass. | 9 |
| Fences, . | J. M. Pitts, . | Sumter, | S. C. | 30 |
| ——— . | N. M. Stratton, . | City of | N. Y. | 23 |
| Filters, . | T. C. Clarke, . | Camden, | N. J. | 9 |
| ——— . | M. W. Warne, . | St. Louis, | Mo. | 9 |
| Finger Rings,—Sheet Metal | I. M. Potter, . | Providence, | R. I. | 2 |
| Fire Escape, . | Wm. Breitenstein, . | City of | N. Y. | 9 |
| ————— . | James Hobbs, . | Columbus, | Ind. | 9 |
| —————,—Portable, . | Israel Grafius, . | Alexandria, | Penna. | 2 |

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| Fire Arms,—Breech-loading | Frederick Jonas, | McConnell's Gr. | Ill. | 2 |
| ———————— | Edward Maynard, . | Washington, | D. C. | 30 |
| ———————— | C. W. Wood, . | Worcester, | Mass. | 9 |
| ————,—Revolving . | A. J. Gibson, . | " | " | 9 |
| ———————— | F. D. Newbury, . | Albany, | N. Y. | 23 |
| ———————— . | E. A. Prescott, . | Worcester, | Mass. | 2 |
| ———————— | August Spellier, . | Philadelphia, | Penna. | 2 |
| ————,—Locks for . | J. P. Lindsay, . | City of | N. Y. | 9 |
| ————,—Magazine | B. T. Henry, . | New Haven, | Conn. | 16 |
| Flour Bolts,—Screens for | David Landis, . | Lancaster, | Penna. | 23 |
| Forge Hammer, . | Edward Pave, . | City of | N. Y. | 9 |
| Freezing Liquids,—Appa's for | F. P. E. Carré, . | Paris, | France, | 2 |
| Fruit Case, . | Doolittle & Carson, | Oswego, | N. Y. | 9 |
| —— Driers, . | H. Beamer, . | Smithburg, | Penna. | 9 |
| Furnaces, . | D. G. Littlefield, | Albany, | N. Y. | 9 |
| Furnace and Cooking Range, | Brown & Bridges, . | Chicago, | Ill. | 2 |
| Furnaces,—Bagasse, | Jones & Charpentier, | New Orleans, | La. | 23 |
| ———— for Steam Boilers, | Henry Wilkins, . | Brownsville, | Penna. | 2 |
| Furniture Caster, . | I. A. Stafford, . | Essex, | N. Y. | 23 |
| Galvanic Plates for Medical Use, | Joseph Hill, . | Brooklyn, | N. Y. | 9 |
| Gas,—Apparatuses for Burning | R. W. Hoit, . | Boston, | Mass. | 9 |
| —— Burners, . | H. H. Dodge, . | Georgetown, | D. C. | 23 |
| —— Fittings,—Finishing | J. W. Lyon, . | Brooklyn, | N. Y. | 30 |
| —— Metres,—Dry . | Gratz & Lloyd, . | Philadelphia, | Penna. | 23 |
| —— Regulators, . | Joseph Foster, . | Richmond, | Va. | 16 |
| ———————— . | J. G. Liffingwell, . | Newark, | N. J. | 16 |
| Gate and Door Swing, | F. W. Kroeber . | Forbestown, | Cal. | 9 |
| Gates, . | J. H. H. Bennett, . | Hunt's Hollow, | N. Y. | 23 |
| ——— . | Hurxthal & Lee, | Boliver, | Ohio, | 2 |
| Gins,—Cotton . | N. A. Patterson, . | Kingston, | Tenn. | 23 |
| Gin Saws,—Filing | Samuel Yeatman, | Providence, | Ala. | 16 |
| Glass,—Manufacture of . | Samuel Wetherill, . | Bethlehem, | Penna. | 16 |
| Gold Separator, . | J. A. Veatch, . | San Francisco, | Cal. | 2 |
| Grain Bins, . | Sylvester Marsh, . | Roxbury, | Mass. | 23 |
| ———,—Machines for Clean'g | John Outram, . | Elmira, | N. Y. | 30 |
| ———,—Elevat'g, Clean'g, &c., | I. A. Stafford, . | Essex, | " | 23 |
| ———,—Drying . | E. I. Bodrio, . | St. Louis, | Mo. | 2 |
| ———,——— and Cooling | J. B. Wheeler, . | Chicago, | Ill. | 23 |
| ——— Separators, | Landers & Lampman, | Afton, | N. Y. | 16 |
| ——— Weighing Machines, | J. B. Mohler, . | Pekin, | Ill. | 23 |
| ———————— | Squeir & Preston, | Battle Creek, | Mich. | 16 |
| Hammer,—Nail . | Charles Carlisle, . | Woodstock, | Vt. | 16 |
| Harmonicons,—Glass or Metal | John Koppe, . | City of | N. Y. | 2 |
| Harness, . | S. L. Bond, . | Greenwood, | S. C. | 23 |
| Harrows, . | C. Watson, . | Cascade, | Va. | 2 |
| ————,—Rotary . | John Brainerd, . | Cleveland, | Ohio, | 2 |
| ———————— | S. S. Hogle, . | " | " | 30 |
| Harvesters, . | T. N. Foster, . | Watertown, | N. Y. | 2 |
| ———— . | F. H. Manny, . | Rockford, | Ill | 2 |
| ————,—Cane . | Achilles St. Dezier, . | Plaquemine, | La. | 9 |
| ——— ——,—Sugar-cane | Johnson & Doyle, | Philadelphia, | Penna. | 2 |
| Harvesting Machines, . | S. T. Lamb, . | N. Washington, | Ind. | 9 |
| ———————— | " . | " | " | 2 |
| Hat Rims,—Curling . | F. S. Sibley, . | Brooklyn, | N. Y. | 9 |
| Hay,—Raking and Pitching | A. J. Preston, . | E. Guilford, | " | 16 |
| Heater,—Fireplace . | D. S. Quimby, . | Brooklyn, | " | 9 |
| Hemp Brakes, . | Ezekiel Guile, . | Waverly, | Mo. | 16 |
| Hoes,—Seeding . | Z. B. Brown, . | Simsbury, | Conn. | 30 |
| Hoops,—Straightening Bale | Charles Hughes, | New Orleans, | La. | 9 |

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| Horse Shoe Machine, . | John McCarty, . | Philadelphia, | Penna. | 16 |
| Hose Protector, . | Bridges & Dieterich, | " | " | 2 |
| Ice Cream Freezers, . | J. S Silva, . | Savannah, | Ga. | 2 |
| Inkstand, . | Samuel Slocomb, | Cambridge, | Mass. | 2 |
| ——— . | W H. Towers, . | City of | N. Y. | 2 |
| Kaleidoscope, . | McNulty & Lyman, | City of | N. Y. | 2 |
| Kegs,—Fastening for Metallic | C. L. Rehn, . | Philadelphia, | Penna. | 9 |
| Keyhole Guard, . | George Wheeler, | City of | N Y. | 9 |
| Knife Cleaner, . | Isaac Detheridge, Jr., | " | " | 23 |
| Label Holder, . | Francis J. Collier, | Philadelphia, | Penna. | 2 |
| Ladle, with Fork Attached, | Warner & Benedict, | Bridgeport, | Conn. | 16 |
| Lamps, . | J. E. Ambrose, . | Batavia, | Ill. | 16 |
| ——— . | F. B. DeKeravenan, . | City of | N. Y. | 23 |
| ——— . | H. W. Dopp, . | Buffalo, | " | 16 |
| ——— . | Albert Kleinsteiber, . | Milwaukie, | Wis. | 9 |
| ——— . | W. H. Racey, . | St. Augustine, | Fla | 30 |
| ———,—Submarine . | L. H. Hasse, . | City of | N. Y. | 9 |
| ———,—Vapor . | W. B. Billings, . | " | " | 2 |
| Lathes, . | Lemuel Postlewait, . | Russellville, | Ohio, | 16 |
| Lifting Jacks, . | W. J. Lane, . | Chappaqua, | N. Y. | 23 |
| Leather,—Oiling . | Lewis Holcomb, . | Granby, | Conn | 9 |
| ———,—Splitting, | S. S. Turner, . | Westborough, | Mass. | 30 |
| ———,—Manufac. of Tanned | Andrew Dietz, . | City of | N Y. | 16 |
| ——— Cloth,—Ornamenting | Auguste Pellet, . | Paris, | France, | 2 |
| Letter Boxes, . | G. C. Jenks, . | City of | N. Y. | 9 |
| Locks,—Freight Car | J. F. Keeler, . | Cleveland, | Ohio, | 2 |
| Locomotives,—Trucks for | D. R. Pratt, . | Worcester, | Mass. | 16 |
| Lubricating Engines, &c., | Joseph Marks, . | Boston, | " | 16 |
| Martingale Rings, . | D. C. Lockwood, . | Derby, | Conn. | 2 |
| Medicines,—Astringent | E. W. Ferris, . | Macon, | Miss. | 16 |
| Mill Bush, . | Ezekiel Casner, . | Penn Yan, | N. Y. | 9 |
| —— for Grinding Coffee, | L. S. Chichester, | City of | " | 9 |
| Mills,—Grinding . | E. J. Hyde, . | Philadelphia, | Penna. | 16 |
| ——————— . | C. W. Shedd, . | Addison, | Ala. | 30 |
| Millstones,—Leveling . | D. A. Balmer, . | Lexington, | Ind. | 23 |
| ————,—Ventilating | Plant & Raith, . | St. Louis, | Mo. | 23 |
| Nail Holes,—Punching . | C. C. Crosby, . | Nantucket, | Mass. | 9 |
| Ordnance,—Breech-loading | Lewis Evans, . | Morgantown, | Va. | 9 |
| ————————— | T. J. Mayall, . | Roxbury, | Mass. | 9 |
| Ore Separators, . | W. O. Bourne, . | City of | N. Y. | 9 |
| Paint Can, . | W. L. Gilroy, . | Philadelphia, | Penna. | 9 |
| —— Mill, | J. A. Berrill, . | Waterville, | N. Y. | 9 |
| Parasol and Fan, . | J. T Eichberg, . | City of | " | 2 |
| Peach Parer, . | W. A. Coe, . | Greensboro', | N. C. | 30 |
| Pen Cleaner, . | Jonathan Warren, . | Brooklyn, | N. Y. | 2 |
| Pianofortes, | Frederick Mathushek, | City of | " | 2 |
| Picker-staff Motion, . | E. H. Graham, . | Manchester, | N. H. | 16 |
| Pic-nic or Excursion Seat, | J. M. Perkins, . | Chicago, | Ill. | 9 |
| Pigs,—Singeing . | A. and E. M. Denny, | Waterford, | Ireland, | 23 |
| Plane Bits,—Securing | T M. Richardson, | Stockton, | Me. | 2 |
| Planters,—Corn . | D., J., and J. F. Herr, | Lancaster, | Penna. | 9 |
| Ploughs, . | M. G. Slemmons, | Cadiz, | Ohio, | 9 |
| ——— . | J A. Stewart, . | Philadelphia, | Miss. | 2 |
| ———,—Securing Points to | H D Rogers, . | Grafton, | Ohio, | 9 |
| Port Lights for Vessels, . | G. C. Gourlay, . | City of | N. Y. | 23 |
| Potato Diggers, . | J. P. Scudder, . | Hightstown, | N. J. | 2 |
| Presses, . | A Randel, . | City of | N. Y. | 23 |

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| Press,—Bookbinders Standing | M. R. Pelletreau, | City of | N. Y. | 2 |
| ——,—Copying . | Cyrus Chambers, Jr., | Philadelphia, | Penna. | 2 |
| ——,—Cotton . | R. M. Brooks, . | Greenville, | Ga. | 2 |
| ———— . | Solon Dike, . | Columbus, | S. C. | 16 |
| Presses,—Cotton, . | P. G. Gardiner, . | City of | N. Y. | 23 |
| ———— . | Murdoch Murchison, . | Denmark, | Tenn. | 23 |
| ———— . | Robert Scott, Jr., | Madison, | Ind. | 9 |
| Press,—Packing . | J. Y. Parce, . | Fairport, | N. Y. | 9 |
| Printing Addresses on Papers, | Samuel Soule, . | Cincinnati, | Ohio, | 2 |
| ———,—Plate . | W. H. Oakes, . | City of | N. Y. | 23 |
| ——— Press Feeder, | Henry Barth, . | Cincinnati, | Ohio, | 23 |
| ———— . | Wm H. Babcock, . | Homer, | N. Y. | 23 |
| Prophylatic Remedies, | C. H. Thomas, . | New Orleans, | La. | 16 |
| Propeller, . | C. J. Schueder, . | Astoria, | N. Y. | 9 |
| Propellers as applied to Vessels, | Henry Stanley, . | Troy, | " | 9 |
| Propelling by Horse Power, | Isaac Stoddard, . | Great Bend, | Penna. | 9 |
| Pumps, . | John Holmes, . | St. Clair, | " | 2 |
| ——— . | W. J Johnson, . | Newton, | Mass. | 23 |
| ——— . | M. E. Rudasill, . | Shelby, | N. C. | 9 |
| ——— . | S. D. Stout, . | Charleston, | Tenn. | 9 |
| Punches, . | R. Humphrey, . | Unionville, | Conn. | 16 |
| Quartz Crusher & Amalgamator, | F. B. Abbott, . | St. Louis, | Mo. | 9 |
| ———,—Crushing and Pulver. | T. A. Morris, . | Green Bay, | Wis. | 23 |
| Railroad Cars,—Bearings for | D. R. Pratt, . | Worcester, | Mass. | 30 |
| ———— over Obstructions, | P. I. Biderman, . | Philadelphia, | Penna. | 9 |
| ————,—Heating | Joseph Pine, . | City of | N. Y. | 9 |
| ————,—Metallic | J. A. Roebling, . | Trenton, | N. J. | 16 |
| Railroads,— Propelling Cars on | James A. Bennet, . | King's County, | N. Y. | 9 |
| Railroad Car Seats and Couches, | Edward Burke, . | Philadelphia, | Penna. | 23 |
| ———————— | J. H. Fisher, . | Placerville, | Cal. | 23 |
| ——— Cars,—Transferring | Josiah Ashenfelder, | Philadelphia, | Penna. | 9 |
| ————,—Ventilation of | Charles Newcomb, . | City of | N. Y. | 9 |
| ———————— | R. B. Wright, . | Norfolk, | Va. | 23 |
| ——— Chairs, . | D. A. Hopkins, . | Bergen, | N. J. | 23 |
| Rakes,—Hay . | S. J. Homan, . | Walden, | N. Y. | 2 |
| Reapers and Mowers, . | G. A. Stephenson, . | Paw Paw, | Mich. | 2 |
| Reaping and Mowing Machines, | McClintock Young, Jr., | Frederick, | Md. | 2 |
| Refrigerators, . | Thomas Byrne, . | Baton Rouge, | La. | 23 |
| Rice Hulling Machines, | Daniel Lombard, | Boston, | Mass. | 23 |
| Rivers,—Delineating Course of | H. Collier, . | Smithville, | Ark. | 30 |
| Roofing Purposes,—Compos. for | J. P. Gay, . | Cincinnati, | Ohio, | 2 |
| Sabre-bayonet Fastening | C. A. McEvoy, . | Richmond, | Va. | 30 |
| Saddles, . | John Commins, . | Charleston, | S. C. | 2 |
| Safes,—Burglar Proof . | J. R. Floyd, . | City of | N. Y. | 16 |
| Sash Fastener, . | P. A Gladwin, . | N. Providence, | R. I. | 2 |
| ———— . | Sylvenus Walker, . | Boston, | Mass. | 9 |
| Saws, . | Darwin Talbot, . | Ironton, | Mo. | 2 |
| Saw-grinding Machine, . | J. D. Custer, . | Norristown, | Penna. | 2 |
| Saws,—Grinding Circular | John Andrews, . | Elmira, | N. Y. | 2 |
| ——,—Adjusting Rake of Muley | C. W. Griffith, . | Dayton, | Ohio, | 23 |
| Saws,—Adjusting Rake of Recip. | J. J. Watson, . | Buffalo, | N. Y. | 23 |
| Sawing Machines, . | J. C. Cline, . | Camden, | N. J. | 23 |
| Scumming,—Apparatus for | Titus Molinier, . | New Orleans, | La. | 9 |
| Seed Planters, . | Pollock & Sener, . | Fredericksb'gh, | Va. | 9 |
| ————,—Cotton . | J. T. Ham, . | Senatobia, | Miss. | 9 |
| Seeding Machines, | J. B. Duane, . | Schenectady, | N. Y. | 2 |
| ———— . | W. M. Garee, . | Cox, | Ohio, | 9 |
| Sewing Machines, | George Fetter, . | Philadelphia, | Penna. | 23 |
| ———— . | A. F. Johnson, . | Boston, | Mass. | 23 |
| Shaft Tug, . | Brown & Babcock, | New Haven, | Conn. | 23 |
| Shafting,—Hanger for . | James P. Collins, . | Troy, | N. Y. | 2 |

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| Shaftings.—Hangers & Boxes for | Wm. Watts, . | Newark, | N. J. | 30 |
| Sheet Metal.—Bending . | Henry Evans, Jr., . | Baltimore, | Md. | 30 |
| ———— ——,—Square Pans of | E. M Roxford, . | Indianapolis, | Ind. | 30 |
| Shingle Machines,—Tilt Tables | J. B Scott, . | " | " | 9 |
| Ships Blocks,—Straps of | Eugene Mack, . | U. S. A. | | 30 |
| Shovels,—Straps for Handles of | C. H. Sayre, . | Utica, | N. Y. | 16 |
| Skates, . | J. F. Blondin, . | Niagara Falls, | " | 2 |
| ——— . | E. H. Graham, . | Manchester, | N. H. | 2 |
| Skate.—Self-adjusting | L. J Masterson, | Newton, | Mass. | 2 |
| Skirts. . | Wm. Heppenstall, . | Springfield, | " | 30 |
| Slivering Machines, | H L. Nichols, . | City of | N. Y. | 16 |
| Smut Machines, . | H. L. Pierce, . | Millpont, | " | 30 |
| Sowing Machines, | Rowland Chapman, | Darlington Dis. | S. C. | 16 |
| ——— ——— ——— . | D C. Teller, . | Beaver Dam, | Wis. | 16 |
| Spoke Machines, . | John Gilchrist, . | Berlin City, | " | 23 |
| Spool Stand,—Revolving | J. P. and F. V Wilson, | Ilion, | N. Y. | 23 |
| Spring.—Carriage | Pressey & Sheets, | Suisun City, | Cal. | 16 |
| ———.—India Rubber Car | T. F. Allen, . | Dyersville, | Iowa, | 23 |
| Stalks, &c.,—Cutting | M E Rudasill, . | Shelby, | N. C. | 23 |
| ———.—Pulling and Cutting | Henry Snyder, . | Dayton, | Ohio, | 9 |
| Staves,—Planing . | Jean de Lihatcheff, | Yaroslawl, | Russia, | 2 |
| Steam Boiler, . | Smith & Mars, . | City of | N. Y. | 2 |
| ——— Boilers.—Prev. Incrust. | Webster & Young, | Portsmouth, | Va. | 23 |
| ——— ———,—Safety Appa's | Charles McCarthy, . | City of | N. Y. | 9 |
| ——— Engines, . | C. C. Barton. . | Troy, | " | 9 |
| ——————,—Pistons for | Robinson & Clark, . | Bellaire, | Ohio, | 9 |
| ——————,—Valve Seats | C. B. Long. . | Worcester, | Mass. | 2 |
| ——————,——— for | G W. Van Deren, . | Big Flatts, | N. Y. | 9 |
| ———————————— | H. E. Woodford, | Watertown, | " | 30 |
| ———————————— | A J. Laird, . | Middletown, | Penna. | 9 |
| ——————.—Pistons for | T. S. La France, | Elmira, | N. Y. | 9 |
| ——————,—Regulator for | J. A. Burnap . | Albany, | " | 16 |
| ——— Gauge, . | Grader & Wursbach, | Memphis, | Tenn. | 9 |
| ——— Generators, . | John Johnson, . | Biddeford, | Me. | 9 |
| ——— Valves, . | J F. Letellier, . | Grand Rapids, | Mich. | 23 |
| Stencil Printing Machine, | A. I Fullam, . | Springfield, | Vt. | 2 |
| Stirrups, . | D. W. Clark, . | Stratford, | Conn. | 9 |
| ——— | J R Williamson, . | Washington, | D. C. | 9 |
| Stone.—Dressing . | Abijah Smith, . | Kingston, | N. Y. | 23 |
| Stoves,—Cooking | Miles Pratt, . | Watertown, | Mass. | 23 |
| —————— . | G. G Wolfe, . | Troy, | N. Y. | 23 |
| Stove Radiators, . | Crossman & Brown, | Warren, | Mass. | 9 |
| Stoves and Ranges,—Cooking | S B Sexton, . | Baltimore, | Md. | 2 |
| Straw Cutters, . | J A. and G. W. Cowdery, | N. Middletown, | Ky. | 30 |
| —————— . | J. H. Lilly, . | Bardstown, | " | 16 |
| Sugar.—Box for Dropping | A. T. Ballantine, . | City of | N. Y. | 23 |
| Tanning, . | Crane & Baldwin, | Anamosa, | Iowa, | 16 |
| ——— . | Andrew Dietz, . | City of | N. Y. | 16 |
| ——— . | Robert Harper, . | Trumbull, | Ohio, | 2 |
| ———,—Compositions for | J. L. Wells, . | St. Louis, | Mo. | 9 |
| Tiles for Flooring . | T J. Macall, . | Roxbury, | Mass. | 16 |
| Tires.—Shrinking . | A. P. Cassel, . | Wataga, | Ill. | 16 |
| Tool Holder, . | Silas Stevens, . | Worcester, | Mass. | 30 |
| Tools.—Sharpening . | J C. Cooke, . | Middletown, | Conn. | 2 |
| Traps.—Animal . | H. V Wildey, . | Philadelphia, | Penna. | 2 |
| Type,—Setting . | Dorsey & Mathers, . | Fairmount, | Va. | 2 |
| ——.—Casting Embossed | I. C. Bryant, . | Philadelphia, | Penna. | 9 |
| Uterine Supporters . | Gustavus Kleinwort, . | Albion, | Ill. | 16 |
| Vehicles,—Running Gear of | F. L Kidder, . | Brooklyn, | N. Y. | 23 |
| ———,—Two-wheeled . | J. W Barnes, . | Murfreesboro', | N. C. | 23 |
| ———,—Velocipede | S. W. Barr, . | Mansfield, | Ohio, | 2 |

| | | | | |
|---|---|---|---|---|
| Warp,—Machines for Dressing | Robert Pilson, | Laurel, | Md. | 30 |
| Wash Bench, | Samuel Wiswell, | Hyde Park, | Vt. | 9 |
| Washing Machine, | John Gray, | Melrose, | N. Y. | 9 |
| ——— ——— | Phelps & Wright, | Sycamore, | Ill. | 2 |
| ——— ——— | J. B. Coffin, | Hayesville, | Ohio, | 23 |
| ——— ——— | S. T. Lamb, | N. Washington, | Ind. | 16 |
| ——— ——— | A. F. Lapham, | City of | N. Y. | 9 |
| Watches, | G. P. Reed, | Roxbury, | Mass. | 2 |
| Water Closets, | Wm. S. Carr, | City of | N. Y. | 23 |
| ——— from Wells,—Elevating | S. and A. Aldrich, | Washington, | D. C. | 23 |
| ——— ——— ——— | John McArthur, | Aurora, | Ill. | 23 |
| ——— Wheel, | J. J. Watson, | Buffalo, | N. Y. | 2 |
| Wheels,—Car | G. S. Bosworth, | Troy, | " | 23 |
| ———,— Carriage | Johnson & Gibson, | Boston, | Mass. | 23 |
| ——— ———,—Hubs for | N. T. Edson, | New Orleans, | La. | 16 |
| ———,—Moulding Cast Iron | G. S. Bosworth, | Troy, | N. Y. | 30 |
| Window Fastener, | E. M. Judd, | New Britain, | Conn. | 16 |
| ——— Blind Fasteners, | A. T. Finch, | Meriden, | " | 16 |
| ——— Net and Sash, | Isaac Wiswell, | Springfield, | Vt. | 9 |
| ——— Sash Supporters, | L. Y. Gardiner, | Amsterdam, | N. Y. | 9 |
| ——— ——— ——— | James McMahan, | Amelia, | Ohio, | 9 |
| Winnowing Machines, | F. H. Manny, | Rockford, | Ill. | 9 |
| Wood-bending Machines, | D. B. Hedden, | Newark, | N. J. | 16 |
| Wrench,—Screw | G. C. Taft, | Worcester, | Mass. | 16 |
| Wrenches,—Wagon | P. D. Van Hoesen, | City of | N. Y. | 2 |

ADDITIONAL IMPROVEMENTS.

| | | | | |
|---|---|---|---|---|
| Fire Arms,—Tape Primer for | T. T. S. Laidley, | U. S. A. | | 9 |
| Lamps, | G. T. Parkhurst, | Baltimore, | Md. | 2 |
| Paper and Letter File, | J. B McEnally, | Clearfield, | Penna. | 2 |
| Ploughs, | W. H. Johnson, | Richmond, | Ark. | 2 |
| Watch Key and Guard Bar, | D. F. Elmer, | Haydensville, | Mass. | 2 |

RE-ISSUES.

| | | | | |
|---|---|---|---|---|
| Door Plates, | J. W. Bliss, | Hartford, | Conn. | 16 |
| Egg Beater, | E. P. Monroe, | City of | N. Y. | 16 |
| Fire Arms,—Breech-load.(2 pat.) | Edward Lindner, | " | " | 2 |
| ———,—Revolving | Smith & Wesson, | Springfield, | Mass. | 9 |
| Harrows, | D. W. Shares, | Hamden, | Conn. | 9 |
| Harvester Rakes, | Owen Dorsey, | Dorseyville, | Md. | 23 |
| Heating Ores, | A. C. Vandyke, | Greenupsburg, | Ky. | 2 |
| Horse-shoe Nails, | Amos Whittemore, | Cambridgeport, | Mass. | 9 |
| Ice,—Hoisting and Storing | Steenburgh & Egnor, | Catskill, | N. Y. | 23 |
| Locks, | T. L. Pye, | City of | " | 16 |
| Needle Case and Index, | C. D. Wheeler, | Bridgeport, | Conn. | 16 |
| Paper and other Fabrics,—Dry'g | E. L. Perkins, | Roxbury, | Mass. | 9 |
| Railroad Cars, | S. J. Seely, | City of | N. Y. | 2 |
| Refrigerator, | B. M. Nyce, | Kingston, | Ind. | 23 |
| Saws,—Grinding | H. R. Burger, | Richmond, | Va. | 16 |
| Seeders,—Percussion | J. R. Rogers, | Sacramento, | Wis. | 9 |
| Steam Boilers, | Louis Lefebre | New Orleans, | La. | 16 |

DESIGNS.

| | | | | |
|---|---|---|---|---|
| Carpets, | E. J. Ney, | Lowell, | Mass. | 2 |
| Carpeting, &c. (13 cases), | H. G. Thompson, | City of | N. Y. | 2 |
| Centre Pieces, | Henry Berger, | " | " | 2 |
| Hat,—Lady's | E. A. Murdoch, | Boston, | Mass. | 2 |
| Heater Fronts, | Elias Tompkins, | Brooklyn, | N. Y. | 9 |
| Spoons, | Alonzo Hebbard, | City of | " | 2 |
| Stoves, | Sailor & Steffe, | Philadelphia, | Penna. | 9 |
| ——— | Smith & Brown, | " | " | 2 |
| Stove,—Plates of a Cooks | " | " | " | 2 |
| ——— Register, | N. S. Vedder, | Troy, | N. Y. | 2 |

## FRANKLIN INSTITUTE.

*Proceedings of the Stated Monthly Meeting, December* 20, 1860.

John Agnew, Vice-President, in the chair.

Isaac B. Garrigues, Recording Secretary.

The minutes of the last meeting were read and approved.

Two letters from the Royal Academy of Science, of Lisbon, Portugal, were read.

Donations to the Library were received from the Commissioners of Patents, the Royal Geographical Society, the Chemical Society, and the Institute of Actuaries, London, Charles Atherton, Esq., Woolwich, and the Literary and Philosophical Society, Liverpool, England; the Ecole des Mines, and the Société d'Encouragement pour l'Industrie Nationale, Paris, and the Société Industrielle, Mulhouse, France; the Académie Royale des Sciences de Lisbonne, Portugal; L. A. Huguet-Latour, Montreal, Canada; the Board of Supervisors, San Francisco, California; the Smithsonian Institute, and F. Emmerick, Esq., Washington City, D. C.; Henry R. Campbell, Esq., Burlington, Vt.; and Profs. John C. Cresson, and John F. Frazer, Philadelphia.

The Periodicals received in exchange for the Journal of the Institute, were laid on the table.

The Treasurer's statement of the receipts and payments for the month of November was read.

The Board of Managers and Standing Committees reported their minutes.

Thirty-one resignations of membership in the Institute were read and accepted.

Candidates for membership in the Institute (6) were proposed, and the candidates proposed at the last meeting (14) duly elected.

Nominations were made for Officers, Managers, and Auditors of the Institute for the ensuing year.

*Resolved*, That the polls for receiving the votes of the members at the annual election for Officers, Managers, and Auditors for the ensuing year, to be held on the third Thursday of January next, be opened at 4 o'clock, P. M., and closed at 8 o'clock, P. M.; and that seven members be appointed by the President to receive the votes and report the results thereof.

Dr. Green exhibited his "Patent Lamp for Burning Fluid;" and, in a series of experiments, showed the impossibility of exploding it. The burning fluid is vaporized by the heat of a spur, reaching downwards into the wick, which is contained in a strong brass tube about seven inches long. The tube is surmounted by a metal cap, having four or more small holes for the emission of the vaporized fluid, at which places it is lighted. This lamp will burn only when in an upright position; if inclined considerably, or inverted, as it probably would be in falling, if the top is removed for the purpose of replenishing the supply, or, the tube taken hold of by the fingers, the flame is instantly extinguished.

Mr. T. Shaw exhibited his Gas-light Cooking Stove, designed to

burn the ordinary carburetted-hydrogen gas that is used for lighting purposes. Mr. Shaw said that this invention, patented Dec. 14, 1858, is designed as a complete substitute for the common coal stove as a cooking apparatus. The construction of the burner is conical, with a gauze disk extending from its smaller end, or outlet for the passage of the gas (which passage is also covered with gauze), for the purpose of supporting the flame, and giving an additional supply of air or oxygen. The first supply is given in the conical chamber, the base of which is open to the external air. The gas on entering said chamber is caused to pass over an inverted cone, which spreads the gas in a thin sheet, and tends to give a current favorable for taking a large supply of air.

The oven, which is placed immediately over one of these burners, is of a cylindric form, and of a capacity of from one to six pies, constructed of an inner and outer casing. The heat from the burner comes in immediate contact with the material to be cooked or baked, and from thence, the cooler currents descending, is caused to ascend from the bottom between the inner and outer casing, and over to the centre of the top of the oven, where there is an opening for its exit.

This stove without any alteration in the result, is modified to suit the many places where it is applicable. The one designed for family use is not very unlike the coal stove in appearance (save that it is much lighter and neater), having a large oven for baking, and places in front for boiling, frying, ironing, &c. It will bake, boil, roast, &c., in the same time as can be done in any stove. The cost is not greater than other fires when not used between meals. The object was first to generate heat with economy, and afterwards to use it with economy.

Any further information will be given on applying to Thomas Shaw, 243 Race Street.

Mr. Alsop exhibited one of his Car Springs, which had been in use on a city passenger car.

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## BIBLIOGRAPHICAL NOTICE.

*Lessons and Practical Notes on Steam, the Steam Engine, Propellers, &c., &c.; for young Marine Engineers, Students, and others.* By the late W. H. King, U. S. N. Revised by Chief Engineer J. W. King, U. S. N. New York: Frederic A. Brady, 24 Ann St., 1860. 8vo., pp. 168.

This is an excellent little work, of much more merit than its modest title-page pretends to. Its scientific explanations are uncommonly clear and easily understood, and it avoids entirely the too frequent affectation of elaborate mathematical formulæ, which so often render works of this class distasteful and incomprehensible to the persons for whom they are intended.

The subjects treated of are those interesting to practical steam engineers, and they are treated lucidly and with sufficient thoroughness for practical purposes. We would note with especial approbation the

chapters on the Indicator, and on Paddle-wheels and Propellers, as containing a great deal of valuable information, not only for students, but for men of advanced attainments.

We hope the book, which is well got up and printed, and illustrated with wood-cuts, will meet with the success to which its merits entitle it. F.

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## METEOROLOGY.

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For the Journal of the Franklin Institute.

### *The Meteorology of Philadelphia.* By James A. Kirkpatrick, A.M.

The Pressure of the Atmosphere.—A period of nine years and six months is insufficient to ascertain the laws of atmospheric pressure. Nevertheless, from observations made regularly and carefully for that time, we may perceive some indication of the laws fixed by the Creator for the government of the atmosphere in which we live. The air is of such extreme mobility that a very slight force produces changes in it which may affect the health and even the life of those who must necessarily be exposed to its influence.

The air, though invisible, is a material substance, and possesses many of the physical properties of the solid and liquid bodies, such as weight, inertia, elasticity, capacity for heat, &c. The weight or pressure of the air may be made manifest to the senses by weighing a vessel filled with it, and again weighing it after the air has been removed by the air pump; or it may be shown by a small disk of leather, which, being moistened and pressed against any smooth surface, so as to expel the intervening air, will adhere to the smooth surface with great force, caused by the pressure of the air upon it. If the air be removed from a tube which has one end closed, and the other end be immersed in water or any other fluid, the pressure of the atmosphere will force the fluid up the tube to a certain height. At the surface of the sea, water will be found to rise in the tube under such circumstances to a height of about 33 feet, while mercury will rise only 29 or 30 ins. If the air has been entirely removed from the tube, the weight of the column which is above the surface of the fluid, in the vessel in which the experiment is made, will be found to be equal, no matter what the fluid used may be. In fact it will always be equal to the weight or pressure of the air which causes it to rise; that is, to the weight of a column of air extending from the surface of the vessel to the top of the atmosphere. This has been found to be about 15 pounds on every square inch. It is evident that if the top of the atmosphere was always at the same distance above the instrument, the column in the tube would always remain at the same height. But if, by any means, the height of the column should be changed, it will of course produce a corresponding change in the height of the fluid in the tube; that is, if the height of the atmosphere is increased, the temperature remaining the same, its weight will be increased, and consequently its increased pressure upon the fluid in the vessel will cause that in the tube

to rise higher. The barometer is an instrument constructed on the principle of the tube in these experiments.

There are several circumstances by which the height of the atmosphere above the barometer may be changed. The instrument may be removed from the level of the sea to the top of a mountain, when, being nearer the top of the atmosphere, the column of mercury in the tube will have a smaller pressure to sustain, and it will not rise as high as it did at the surface of the sea. Or, if the barometer remains in the same position, the distance to the top of the atmosphere, and consequently its pressure upon the instrument, may be changed by a change of temperature, by the passage of a storm, or by other means.

TABLE I.—*Showing the mean height of the barometer at the hours of observation at Philadelphia, as deduced from observations continued for nine years and a half, reduced to the freezing point, but not corrected for altitude.*

| Months. | 7 A. M. | 2 P. M. | 9 P. M. | Monthly means. |
|---|---|---|---|---|
| January, . | 29·978 | 29·940 | 29·965 | 29·961 |
| February, . | 29·915 | 29·867 | 29 896 | 29 892 |
| March, . | 29·845 | 29·789 | 29·821 | 29·818 |
| April, . | 29·800 | 29·758 | 29·787 | 29·782 |
| May, . | 29·843 | 29·809 | 29 830 | 29.827 |
| June, . | 29·825 | 29·791 | 29·803 | 29·806 |
| July, . | 29·861 | 29·831 | 29 846 | 29·846 |
| August, . | 29·879 | 29·851 | 29·869 | 29·866 |
| September, . | 29 985 | 29·943 | 29·961 | 29 963 |
| October, . | 29·937 | 29·895 | 29·915 | 29 916 |
| November, . | 29·935 | 29 896 | 29·921 | 29·917 |
| December, | 29·953 | 29·916 | 29·939 | 29·936 |
| Annual Means, | 29·893 | 29·854 | 29·877 | 29·875 |
| Winter, . | 29·949 | 29·908 | 29·932 | 29·930 |
| Spring, . | 29 829 | 29·785 | 29·813 | 29 809 |
| Summer, . | 29·859 | 29·828 | 29 844 | 29·844 |
| Autumn, . | 29·952 | 29·911 | 29·932 | 29 932 |

In consequence of the ease with which masses of air move from one place to another, the barometric column is incessantly oscillating. These changes are not, however, accidental, but seem to follow certain fixed laws, which at present are but partially known. There is a daily pulsation or oscillation in the pressure of the atmosphere, showing two maxima and two minima in the course of 24 hours. The maxima occur about 10 A.M. and 10 P.M., and the minima at about 4 A.M. and 4 P.M. The above table shows the height of the barometric column for the three hours of observation, as deduced from observations made at Philadelphia for nine years and six months. The barometer used was made by Francis for the Committee on Meteorology of the Franklin Institute. It has a flexible leather bottom and is furnished with a short brass scale. It has been frequently compared with a standard instrument and is believed to be perfectly reliable. The height of the fountain of the barometer above mean tide in the River Delaware is fifty feet; and the geographical position of my residence, where the

observations were made, as fixed by the determinations of the Coast Survey and by measurement, is lat. 39° 57′ 28″ N., long. 75° 10′ 28″ W. from Greenwich. The observations have all been reduced to the temperature of 32° Fah., but have *not* been reduced to the level of the sea.

Though these observations were not made at the hours of daily maxima and minima, yet they show very clearly a regular wave or pulsation of the atmospheric pressure, greater at the morning and evening, and less at the mid-day observations. They also show that the height of the barometric column at 9 P. M. is very near the average height of the three observations; the difference of the two for the whole period of nine years and a half being only two one-thousandths of an inch.

Table II.—*Showing the mean daily range of the barometric column at Philadelphia for every month, season, and year, from July,* 1851, *till December,* 1860.

| Months. | 1851. | 1852. | 1853 | 1854. | 1855. | 1856. | 1857. | 1858. | 1859. | 1860. | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Inch. | Inch. | Inch. | Inch. | Inch. | Inch. | Inch. | Inch | Inch. | Inch. | Inch. |
| January, | | ·202 | ·196 | ·249 | ·206 | 207 | ·220 | ·208 | ·206 | ·159 | ·206 |
| February, | | ·286 | ·205 | ·251 | ·159 | ·228 | ·180 | ·190 | ·230 | ·209 | ·215 |
| March, | | ·241 | ·194 | ·195 | ·174 | ·165 | ·200 | ·171 | ·250 | ·133 | ·191 |
| April, | | ·175 | ·208 | ·221 | ·165 | ·180 | ·188 | ·150 | ·160 | ·166 | ·179 |
| May, | | ·133 | ·120 | ·091 | ·095 | ·133 | ·144 | ·158 | ·111 | ·100 | ·121 |
| June, | | ·120 | ·089 | ·081 | ·125 | ·083 | ·094 | ·072 | ·116 | ·088 | ·096 |
| July, | ·110 | ·110 | ·082 | ·079 | ·086 | ·095 | ·070 | ·094 | ·099 | ·112 | ·094 |
| August, | ·076 | ·082 | ·089 | ·083 | ·131 | ·092 | ·115 | ·095 | ·070 | ·090 | ·092 |
| September, | ·114 | ·124 | ·121 | ·130 | ·135 | ·082 | ·109 | ·135 | ·119 | ·143 | ·121 |
| October, | ·151 | ·149 | ·170 | ·135 | ·131 | ·133 | ·161 | ·143 | ·140 | ·119 | ·143 |
| November, | ·249 | ·204 | ·193 | ·188 | ·187 | ·147 | ·181 | ·136 | ·193 | ·197 | ·187 |
| December, | ·218 | ·266 | ·171 | ·174 | ·261 | ·225 | ·205 | ·206 | ·199 | ·196 | ·212 |
| Annual range, | | ·174 | ·153 | ·156 | ·155 | ·147 | ·156 | ·146 | ·158 | ·143 | ·154 |
| Winter, | | ·235 | ·222 | ·224 | ·180 | ·232 | ·208 | 201 | ·214 | ·189 | ·212 |
| Spring, | | ·183 | ·174 | ·169 | ·145 | ·159 | ·177 | ·160 | ·174 | ·133 | ·164 |
| Summer, | | ·104 | 087 | 081 | ·114 | ·090 | ·093 | ·087 | ·095 | ·097 | ·094 |
| Autumn, | ·171 | ·159 | ·161 | ·151 | ·151 | ·121 | ·150 | ·138 | ·151 | ·153 | ·151 |

Besides this hourly wave of pressure, we also notice a daily undulation in comparing a day with that which immediately precedes it. This daily change of pressure at Philadelphia for the different months, seasons, and years, is exhibited in the second table, which contains the mean daily range of the barometric column. This table is prepared by comparing one day's observations with those of the same hours of the preceding day. For example, if the corrected height of the mercury on Monday is, at 7 A. M., 29·786 ins., at 2 P. M., 29·698 ins., and at 9 P. M., 29·892 inches, and on Tuesday at the same hours respectively, 30·325, 30·252, and 30·320 inches, then the mean daily range for Tuesday would be the mean of the differences for each hour taken separately. The difference at 7 A. M. is ·539 inch, at 2 P. M., ·554 inch, and at 9 P. M., ·428 inch, and the average of these three numbers, ·507, is the mean daily range of the mercury for Tuesday.

The mean for the month is obtained by combining the means for all the days of the month; the mean for the seasons by combining the means for the three months composing the season; and that for the year by taking the average of the twelve monthly means.

It will be seen by inspecting the table that the mean daily range changes regularly with the months and seasons; it being greater in the winter months and less in summer, while the average for the different years remains nearly stationary.

The third table indicates a wave of pressure extending over a still greater period of time, but on being referred to months and seasons agreeing remarkably with the indications of the mean daily range.

TABLE III.—*Showing the extreme monthly, annual, and quarterly oscillation of the barometric column at Philadelphia, from July,* 1851, *till December,* 1860, *inclusive.*

| Months. | 1851. | 1852. | 1853. | 1854. | 1855. | 1856. | 1857. | 1858. | 1859. | 1860. | Mean. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Inch. | Inch. | Inch. | Inch. | Inch. | Inch | Inch. | Inch. | Inch. | Inch. | Inch. |
| January, | | 1·458 | 1 763 | 1·087 | 1·447 | 1·115 | 1·275 | 1·121 | 1·088 | ·806 | 1·240 |
| February, | | 1 350 | 1 278 | 972 | ·664 | 1·243 | 1·039 | ·849 | ·913 | 1·259 | 1·063 |
| March, | | 1·299 | 1·025 | 1·102 | ·962 | ·928 | 1·075 | 965 | 1·145 | ·725 | 1·025 |
| April, | | 1·126 | ·994 | 1 269 | ·945 | ·996 | 1 077 | ·724 | 1·193 | ·984 | 1·034 |
| May, | | ·806 | ·797 | ·568 | ·675 | ·755 | ·791 | ·864 | ·664 | ·571 | ·721 |
| June, | | ·849 | ·480 | ·549 | ·625 | ·501 | ·712 | ·436 | ·632 | ·880 | 629 |
| July, | ·577 | ·678 | ·537 | ·407 | ·490 | ·468 | ·602 | ·590 | ·658 | ·484 | ·549 |
| August, | ·582 | ·564 | ·500 | ·481 | ·741 | ·690 | ·501 | ·518 | ·327 | ·394 | ·533 |
| September, | ·776 | ·869 | ·700 | ·731 | ·601 | ·641 | ·614 | ·874 | ·841 | ·716 | ·737 |
| October, | ·720 | ·819 | ·819 | ·891 | ·732 | 652 | 1.187 | ·936 | ·723 | ·963 | ·844 |
| November, | 1·396 | 1·055 | 1·035 | 1·112 | ·898 | 1·133 | 1.356 | ·630 | ·902 | 1·057 | 1 057 |
| December, | ·989 | 1·079 | 1·173 | 1·260 | 1·499 | 1 578 | 1.140 | 1·253 | ·900 | 1·133 | 1·200 |
| Annual oscillation, | | 1·687 | 1·763 | 1·360 | 1·664 | 1·578 | 1·626 | 1·325 | 1·585 | 1·319 | 1 545 |
| Winter, | | 1·620 | 1·763 | 1·356 | 1·447 | 1·499 | 1·578 | 1·265 | 1·269 | 1·300 | 1·455 |
| Spring, | | 1·638 | 1·114 | 1·360 | 1 038 | 1·039 | 1 141 | ·965 | 1·145 | ·984 | 1·158 |
| Summer, | | ·749 | ·629 | ·636 | ·860 | ·698 | ·889 | ·590 | ·682 | ·880 | ·736 |
| Autumn, | 1·396 | 1·131 | 1·035 | 1·131 | ·898 | 1·133 | 1·461 | ·975 | 1·000 | 1·065 | 1·122 |

Table III. contains the monthly, annual, and quarterly oscillations of the barometric column. It is prepared by taking the difference between the highest and lowest stand of the mercury for each month, each year, and each quarter. The numbers given are probably less than the actual difference, as they, generally, only indicate results obtained by three daily observations (at 7 A.M., 2 P.M., and 9 P.M.), and the actual maximum and minimum may have been reached and passed at some other hour of the day. They show, however, a distinct pulsation or wave of barometric disturbances, which reaches its maximum in January and its minimum in August, following a pretty regular curve from month to month. This wave is seen more distinctly in comparing the various seasons. The average oscillations for the summer are only about half as great as for the winter, while the disturbances for the spring are but slightly greater than for the autumn. The greatest oscillation of the mercury for any one year was 1·763 inches in 1853. The lowest stand of the mercury observed was 28·884

inches on the 21st of April, 1852, and the highest was 30·704 inches on the 28th of January, 1853, so that the total oscillation for the time of observation is 1·82 inches.

But there are indications of still greater atmospheric pulsations. By inspecting the fourth table, containing the average height of the barometric column for every month, it will be seen that, with the exception of the month of September, the means for the different months for the series of years there given, form a regular curve, which attains its greatest height in January, descends rapidly till April, and then rises gradually again till December or January; or perhaps there may be a double wave, the first or great undulation extending from January till September, and then a smaller one from September till January. The number of years over which this series of observations extends not being great enough to determine this point with accuracy.

Again, the line of annual means in Table IV. indicates a barometric wave or pulsation extending probably over a period of nine or ten years. It will be seen that the annual mean of 1853 appears to be a maximum, that the means for the ensuing years descend gradually until they reach a minimum in 1856, or between 1856 and 1857, and then again begin to rise, forming a curve of such a shape as to indicate another maximum about the year 1862 or 1863. It will, however, require a longer period of observation before the truth of such a law can be ascertained.

TABLE IV.—*Average height of the barometric column at Philadelphia for every month, season, and year, from July,* 1851, *till December,* 1860, *reduced to the freezing point, but not corrected for altitude. Height above mean tide* 50 *feet.*

| Months. | 1851. | 1852. | 1853. | 1854. | 1855. | 1856. | 1857. | 1858. | 1859. | 1860. | Means. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Inch. | Inch. | Inch. | Inch. | Inch. | Inch. | Inch. | Inch. | Inch. | Inch. | Inch. |
| January, . | | 29·880 | 29·962 | 30·008 | 29·971 | 29·870 | 30·06 | 29·951 | 30·003 | 29·941 | 29·961 |
| February, . | | 29·857 | 29·930 | 29·957 | 29·840 | 29·731 | 30·034 | 29·874 | 29·885 | 29·924 | 29·892 |
| March, . | | 29·887 | 29·873 | 29·841 | 29·797 | 29·773 | 29·836 | 29·807 | 29·758 | 29·794 | 29·818 |
| April, . | | 29·638 | 29·850 | 29·870 | 29·856 | 29·814 | 29·733 | 29·751 | 29·701 | 29·824 | 29·782 |
| May, . | | 29·876 | 29·888 | 29·849 | 29·807 | 29·785 | 29·748 | 29·805 | 29·874 | 29·810 | 29·827 |
| June, . | | 29·844 | 29·988 | 29·824 | 29·739 | 29·781 | 29·663 | 29·813 | 29·861 | 29·740 | 29·806 |
| July, . | 29·743 | 29·900 | 29·955 | 29·925 | 29·851 | 29·809 | 29·808 | 29·827 | 29·852 | 29·791 | 29·846 |
| August, . | 29·868 | 29·952 | 29·912 | 29·946 | 29·923 | 29·765 | 29·811 | 29·829 | 29·827 | 29·832 | 29·866 |
| September, . | 30·034 | 30·028 | 29·975 | 30·021 | 29·982 | 29·886 | 29·936 | 29·922 | 29·858 | 29·989 | 29·963 |
| October, . | 29·883 | 29·975 | 29·975 | 29·994 | 29·831 | 29·982 | 29·830 | 29·906 | 29·845 | 29·936 | 29·916 |
| November, . | 29·914 | 29·921 | 30·159 | 29·833 | 29·948 | 29·956 | 29·883 | 29·797 | 29·965 | 29·79 | 29·917 |
| December, . | 30·020 | 29·971 | 29·868 | 29·885 | 29·919 | 29·961 | 29·899 | 29·974 | 29·926 | 29·93 | 29·936 |
| Annual means, | | 29·894 | 29·945 | 29·913 | 29·872 | 29·834 | 29·837 | 29·855 | 29·863 | 29·859 | 29·875 |
| Winter, . | | 29·919 | 29·954 | 29·944 | 29·893 | 29·840 | 30·019 | 29·908 | 29·954 | 29·930 | 29·930 |
| Spring, . | | 29·800 | 29·870 | 29·853 | 29·820 | 29·791 | 29·772 | 29·788 | 29·778 | 29·809 | 29·809 |
| Summer, . | | 29·899 | 29·955 | 29·898 | 29·838 | 29·785 | 29·760 | 29·823 | 29·847 | 29·788 | 29·844 |
| Autumn, . | 29·941 | 29·975 | 30·036 | 29·949 | 29·920 | 29·941 | 29·883 | 29·874 | 29·889 | 29·906 | 29·932 |

NOVEMBER.—The temperature of November was about one degree above the average for the last ten years, and one degree below the temperature of November, 1859. The warmest day was the first, of which the mean temperature was 69°, and the thermometer indicated the maximum (80°) on the same day. The 25th of the month was the coldest day, the mean temperature being 23·3°. The minimum temperature (16°) occurred on the morning of the same day. The maximum temperature was higher, and the minimum lower, than for any

previous month of November for the ten years of observation. The nearest approach to such a condition was in November, 1857, when the highest temperature was 78° and the lowest 19°. The temperature was at or below the freezing point on six days of the month.

The first ice of the season was observed on the morning of the 21st, and the first snow occurred on the afternoon of the same day. The ice was less than the tenth of an inch in thickness, and the snow continued only for a few minutes.

Rain fell on twelve days to the aggregate depth of 6·057 inches, which is about twice the usual quantity for the month, and the greatest amount for November during the period for which the observations have been taken. In November, 1852, 6·050 inches fell, which is the nearest approach to the rain of last November. Nearly one-half of the amount of rain for the month fell on the 3d. On that day 2·998 inches fell.

The force of vapor at 2 P. M. was less than usual, but at 7 A. M. and 9 P. M. it stood at about the average of the same hours for the last ten years. The relative humidity was again below the average.

The pressure of the atmosphere was less than usual, being twelve-hundredths of an inch less than the average for ten years, and nearly two-tenths of an inch less than it was in November, 1859.

*A Comparison of some of the Meteorological Phenomena of November,* 1860, *with those of November,* 1859, *and of the same month for ten years, at Philadelphia.*

| | Nov., 1860. | Nov., 1859. | Nov., 10 years. |
|---|---|---|---|
| Thermometer.—Highest, | 80° | 67° | 80° |
| " Lowest, | 16 | 27 | 16 |
| " Daily oscillation, | 14·43 | 18·60 | 13·41 |
| " Mean daily range, | 5·53 | 7·30 | 5·77 |
| " Means at 7 A. M., | 43·30 | 42·63 | 41·23 |
| " " 2 P. M., | 50·53 | 53·35 | 50·53 |
| " " 9 P. M., | 45·33 | 46·48 | 44·45 |
| " " for the month, | 46·39 | 47·49 | 45·40 |
| Barometer.—Highest, | 30·305 in. | 30·338 in. | 30·661 in. |
| " Lowest, | 29·348 | 29·436 | 29·117 |
| " Mean daily range, | ·197 | ·193 | ·187 |
| " Means at 7 A. M., | 29·821 | 29 990 | 29·935 |
| " " 2 P. M., | 29·773 | 29·940 | 29 896 |
| " " 9 P. M., | 29·792 | 29·965 | 29 921 |
| " " for the month, | 29·795 | 29·965 | 29·917 |
| Force of Vapor.—Means at 7 A. M., | ·234 in. | ·227 in. | 231 in. |
| " " " 2 P. M., | ·228 | ·241 | ·234 |
| " " " 9 P. M., | ·236 | ·241 | ·238 |
| Relative Humidity.—Means at 7 A. M., | 76 per ct. | 77 per ct. | 78 per ct. |
| " " " 2 P. M., | 57 | 56 | 59 |
| " " " 9 P. M., | 71 | 71 | 74 |
| Rain, amount in inches, | 6·057 | 3·796 | 3·680 |
| Number of days on which rain fell, | 12 | 8 | 10 |
| Prevailing winds, | N.81°25′W·333 | N.54°52′W·206 | N.67°59′W·245 |

The sky was clear or free from clouds on four days of the month, and there were six days on which the sky was completely covered with clouds at the hours of observation.

AUTUMN.—The Autumn, comprising the months of September, October, and November, was one degree warmer than the autumn of 1859, and very near the average temperature for the last ten years.

The pressure of the atmosphere was greater than for the Autumn of 1859, but it still continued to be less than the average.

The force of vapor was greater than for the preceding Autumn, but it was still less than the average; while the relative humidity was almost precisely the same as for the Autumn for ten years, as will appear by an examination of the annexed table of comparisons.

The rain was about one inch less than fell in the Autumn of 1859, but it was three inches and a half above the average.

The number of days on which rain fell was 32, being five more than usual.

The prevailing winds during this Autumn came from a point a little south of west, while their average direction for ten years is about twice as far north of west.

*A Comparison of the* AUTUMN *of* 1860, *with that of* 1859, *and of the same season for ten years, at Philadelphia.*

| | Autumn, 1860. | Autumn, 1859. | Autumn, for 10 years. |
|---|---|---|---|
| Thermometer.—Highest, . . . . | 92° | 82° | 95° |
| " Lowest, . . | 16 | 27 | 16 |
| " Daily oscillation, . | 16·23 | 18·30 | 15·35 |
| " Mean daily range, . | 5·50 | 5·78 | 5·37 |
| " Means at 7 A. M., . | 51·72 | 50·21 | 51·59 |
| " " 2 P. M., . | 62·33 | 61·78 | 62·82 |
| " " 9 P. M., . | 54·99 | 54·00 | 55·42 |
| " " for the autumn, | 56·35 | 55·33 | 56·61 |
| Barometer.—Highest, . . . . | 30·313 in. | 30·338 in. | 30·661 in. |
| " Lowest, . . . . | 29·248 | 29·338 | 29 012 |
| " Mean daily range, . . | ·153 | ·151 | ·151 |
| " Means at 7 A. M., . | 29·929 | 29·910 | 29·952 |
| " " 2 P. M., . . | 29·881 | 29·866 | 29·911 |
| " " 9 P. M., . | 29·909 | 29·893 | 29·932 |
| " " for the autumn, | 29·906 | 29 889 | 29·932 |
| Force of Vapor.—Means at 7 A. M., | ·327 in | ·308 in. | ·339 in. |
| " " " 2 P. M., . | ·343 | ·326 | ·357 |
| " " " 9 P. M., | ·348 | ·331 | ·356 |
| Relative Humidity.—Means at 7 A. M., | 78 per ct. | 77 per ct. | 78 per ct. |
| " " " 2 P. M., | 56 | 55 | 57 |
| " " " 9 P. M., | 74 | 72 | 74 |
| Rain, amount in inches, . . . | 13·649 in. | 14·785 | 10·208 |
| Number of days on which rain fell, | 32 | 26 | 27 |
| Prevailing winds, . . . . . | s. 84°34′w·251 | n 69°12′w·281 | n 77°39′w·237 |

*Abstract of Meteorological Observations for October, 1860; made in Philadelphia, Franklin, and Somerset Counties, Pennsylvania, for the Committee on Meteorology of the Franklin Institute.*

PHILADELPHIA.—Lat. 39° 57′ 28″ N. Long. 75° 10′ 28″ W. Height above the sea 50 feet. Prof. J. A. KIRKPATRICK, Observer.

| 1860. Oct. | Barometer. Mean. | Barometer. Mean daily range | Thermometer. Mean. | Thermometer. Daily oscillation. | Thermometer. Mean daily range. | Force of vapor. 2 P.M. | Relative humidity. 2 P.M. | Rain. | Prevail'g winds. |
|---|---|---|---|---|---|---|---|---|---|
| | Inch. | Inch. | ° | ° | ° | Inch. | Per ct. | Inches. | Direc. |
| 1 | 30·150 | ·155 | 53·7 | 12 | 5·3 | ·361 | 86 | 0·230 | S E. |
| 2 | 29·965 | ·184 | 69·0 | 21 | 15·3 | ·622 | 65 | | S W. |
| 3 | 30·119 | ·154 | 62·3 | 15 | 6·7 | ·380 | 52 | | N N E. |
| 4 | 30·036 | ·083 | 60·5 | 15 | 3·8 | ·468 | 73 | 0·020 | (var.) |
| 5 | 29·888 | ·147 | 65·5 | 14 | 5·0 | ·507 | 62 | 0·003 | S W. |
| ☾ 6 | 29·987 | ·098 | 52·3 | 16 | 13·2 | ·202 | 48 | | N W. |
| 7 | 29·868 | ·171 | 51·5 | 22 | 8·5 | ·217 | 41 | 0·625 | (var.) |
| 8 | 29·423 | ·445 | 61·0 | 22 | 9·5 | ·556 | 71 | 0·105 | W. |
| 9 | 29·572 | ·149 | 51·8 | 13 | 9·2 | ·225 | 47 | | W N W |
| 10 | 29·728 | ·155 | 58·5 | 23 | 6·7 | ·301 | 42 | | S W. |
| 11 | 29·686 | ·067 | 63·7 | 16 | 5·2 | ·446 | 61 | | S W. |
| 12 | 29·946 | ·259 | 52·2 | 15 | 11·5 | ·224 | 43 | 0·015 | N W. |
| 13 | 30·042 | ·096 | 50·2 | 21 | 3·7 | ·187 | 40 | | (var.) |
| ● 14 | 30·026 | ·032 | 43·5 | 16 | 9·0 | ·234 | 70 | 0·706 | N N E. |
| 15 | 30·043 | ·050 | 44·7 | 16 | 6·2 | ·231 | 64 | | (var.) |
| 16 | 30·040 | ·053 | 49·0 | 21 | 4·3 | ·238 | 48 | | W S W |
| 17 | 29·956 | ·084 | 53·8 | 23 | 4·8 | ·280 | 50 | | S S W. |
| 18 | 30·091 | ·135 | 58·0 | 19 | 6·2 | ·314 | 46 | | N E. |
| 19 | 29·961 | ·130 | 53·0 | 12 | 5·7 | ·252 | 52 | 0·200 | N E. |
| 20 | 29·870 | ·105 | 53·7 | 5 | 2·7 | ·389 | 90 | 2·083 | N E. |
| ☽ 21 | 29·821 | ·049 | 57·8 | 9 | 4·2 | ·455 | 88 | 0·075 | N E. |
| 22 | 29·885 | ·064 | 59·0 | 11 | 1·5 | ·414 | 72 | | (var.) |
| 23 | 26·790 | ·096 | 58·2 | 13 | 1·5 | ·339 | 57 | | S W. |
| 24 | 29·813 | ·082 | 58·5 | 16 | 0·7 | ·296 | 48 | | S W. |
| 25 | 29·918 | ·104 | 57·2 | 19 | 1·7 | ·326 | 53 | | (var.) |
| 26 | 29·886 | ·032 | 60·7 | 21 | 3·5 | ·465 | 61 | | S W. |
| 27 | 30·107 | ·221 | 52·8 | 18 | 7·8 | ·252 | 45 | | S W. |
| 28 | 30·198 | ·099 | 55·0 | 17 | 2·5 | ·315 | 58 | | E N E. |
| ○ 29 | 30·104 | ·095 | 63·3 | 18 | 8·3 | ·507 | 74 | | (var.) |
| 30 | 30·074 | ·037 | 64·0 | 9 | 1·3 | ·625 | 95 | 0·337 | S E. |
| 31 | 30·013 | ·062 | 67·3 | 11 | 3·3 | ·639 | 76 | 0·286 | S E. |
| Means | 29·936 | ·119 | 56·8 | 16 | 5·8 | 363 | 61 | 4·085 | S 76° W |

CHAMBERSBURG, Franklin Co. Lat. 39° 58′ N. Long. 77° 45′ W. Height 618 ft. WM. HEYSER, Jr., Obs.

| 1860. Oct. | Barom. Mean. | Thermom. Mean. | Thermom. Mean daily range. | Force of vapor. 2 P.M. | Relative humidity. 2 P.M. | Rain. | Prevail'g winds. |
|---|---|---|---|---|---|---|---|
| | Inch. | ° | ° | Inch. | Per ct | Inch. | Direc. |
| 1 | 29·456 | 52·3 | 4·3 | ·420 | 93 | } 1·410 | (var.) |
| 2 | 29·380 | 66·7 | 14·3 | ·666 | 77 | | N W. |
| 3 | 29·479 | 63·0 | 3·7 | ·509 | 74 | | E. |
| 4 | 29·578 | 63·0 | 3·3 | ·562 | 94 | 0·100 | S E. |
| 5 | 29·247 | 65·7 | 3·3 | ·608 | 80 | | W. |
| ☾ 6 | 29·361 | 55.7 | 10·0 | ·354 | 66 | | W. |
| 7 | 29·208 | 51·0 | 7·3 | ·336 | 70 | } 0·457 | E. |
| 8 | 28·804 | 59·0 | 8·0 | ·549 | 89 | | W. |
| 9 | 28·985 | 50·0 | 8·0 | ·268 | 60 | | W. |
| 10 | 29·054 | 56·7 | 4·3 | ·393 | 59 | | S. |
| 11 | 29·066 | 59·3 | 4·7 | ·498 | 70 | 0·147 | S W. |
| 12 | 29·314 | 49·0 | 12·3 | ·207 | 53 | | (var.) |
| 13 | 29·38. | 47·7 | 2·0 | ·283 | 79 | | S W. |
| ● 14 | 29·398 | 45·0 | 3·3 | ·283 | 79 | 0·180 | (var.) |
| 15 | 29·430 | 48·0 | 2·3 | ·295 | 68 | | (var.) |
| 16 | 29·368 | 54·0 | 6·7 | ·296 | 59 | | (var.) |
| 17 | 29·266 | 46·3 | 7·7 | ·297 | 92 | 0·273 | S E. |
| 18 | 29·410 | 54·3 | 7·3 | ·439 | 88 | | S E. |
| 19 | 29·324 | 52·7 | 1·7 | ·308 | 69 | 1·000 | (var.) |
| 20 | 29·223 | 51·7 | 1·0 | ·348 | 86 | 0·514 | S E. |
| ☽ 21 | 29·144 | 57·7 | 6·0 | ·460 | 83 | | S E. |
| 22 | 29·244 | 61·7 | 6·0 | ·376 | 59 | 0·105 | W. |
| 23 | 29·143 | 58·0 | 5·7 | ·373 | 62 | | S W. |
| 24 | 29·202 | 57·3 | 3·0 | ·325 | 61 | | W. |
| 25 | 29·251 | 54·7 | 5·0 | ·451 | 73 | | S W. |
| 26 | 29·271 | 59·3 | 4·0 | ·385 | 52 | | (var.) |
| 27 | 29·508 | 52·0 | 6·7 | ·538 | 65 | | S E. |
| 28 | 29·537 | 57·3 | 5·3 | ·443 | 82 | | (var.) |
| ○ 29 | 29·471 | 63·3 | 6·0 | ·509 | 74 | | N E. |
| 30 | 29·426 | 65·3 | 2·0 | ·635 | 90 | } 0·308 | S E. |
| 31 | 29·367 | 67·0 | 1·7 | ·644 | 85 | | S W. |
| Means | 29·294 | 56·5 | 5·4 | ·414 | 74 | 4·494 | S 6° E |

SOMERSET, Somerset Co. Lat. 40° N. Long. 79° 3′ W. Height 2195 feet. GEO. MOWRY, Observer.

| 1860. Oct. | Barom. Mean. | Thermom. Mean. | Thermom. Mean daily range. | Force of vapor. 2 P.M. | Relative humidity. 2 P.M. | Rain. | Prevail'g winds. |
|---|---|---|---|---|---|---|---|
| | Inch. | ° | ° | Inch. | Per ct. | Inch. | Direc. |
| 1 | 27·817 | 54·7 | 13·0 | ·537 | 100 | 0·705 | (var.) |
| 2 | 27·802 | 64·7 | 11·0 | ·581 | 71 | 1·633 | W. |
| 3 | 27·850 | 59·0 | 5·7 | 509 | 74 | | S. |
| 4 | 27·762 | 63·0 | 4·0 | ·692 | 85 | 0·412 | S |
| 5 | 27·729 | 62·0 | 3·7 | ·488 | 62 | | W N W |
| ☾ 6 | 27·743 | 51·0 | 11·0 | 331 | 63 | | (var.) |
| 7 | 27·580 | 58·0 | 12·3 | ·475 | 64 | } 1·631 | S W. |
| 8 | 27·278 | 55·0 | 8·3 | ·433 | 73 | | N W. |
| 9 | 27·406 | 48·3 | 8·0 | ·281 | 58 | | W N W |
| 10 | 27·414 | 55·0 | 6·7 | ·393 | 59 | | S W. |
| 11 | 27·484 | 52·0 | 8·3 | ·309 | 60 | | W N W |
| 12 | 27·712 | 39·0 | 13·0 | ·175 | 50 | | N W. |
| 13 | 27·760 | 41·3 | 3·0 | ·180 | 43 | | N W. |
| ● 14 | 27·780 | 41·3 | 6·0 | ·204 | 68 | | N E. |
| 15 | 27·798 | 40·0 | 4·7 | ·209 | 58 | | W. |
| 16 | 27·763 | 44·7 | 7·3 | ·216 | 46 | | (var.) |
| 17 | 27·694 | 45·7 | 9·7 | ·278 | 81 | 0·100 | (var.) |
| 18 | 27·797 | 45·0 | 5·3 | ·311 | 92 | 0·042 | E. |
| 19 | 27·712 | 47·7 | 2·7 | ·223 | 64 | 0·072 | N E. |
| 20 | 27·574 | 49·3 | 3·0 | ·348 | 86 | 0·173 | E. |
| ☽ 21 | 27·536 | 53·3 | 4·7 | ·369 | 66 | | E. |
| 22 | 27·638 | 50·3 | 3·0 | ·342 | 77 | | (var.) |
| 23 | 27·558 | 50·0 | 4·3 | ·351 | 70 | 0·024 | W S W |
| 24 | 27·611 | 50·0 | 4·7 | ·309 | 60 | | (var.) |
| 25 | 27·656 | 50·7 | 8·7 | ·345 | 54 | | S. |
| 26 | 27·694 | 52·3 | 3·0 | ·362 | 55 | | (var.) |
| 27 | 27·819 | 52·0 | 1·7 | ·359 | 58 | | E S E. |
| 28 | 27·824 | 54·3 | 4·3 | ·376 | 69 | | E S E. |
| ○ 29 | 27·804 | 56·7 | 5·0 | ·429 | 91 | 0·615 | E S E. |
| 30 | 27·817 | 60·3 | 3·7 | ·458 | 76 | 0·032 | E. |
| 31 | 27·770 | 61·0 | 2·0 | ·489 | 74 | | E S E. |
| Means | 27·684 | 51·6 | 6·2 | ·366 | 68 | 5·439 | S 53° W |

*Abstract of Meteorological Observations for October, 1860; made in Adams, Dauphin, Northumberland, Centre, and Erie Counties, Pennsylvania, for the Committee on Meteorology of the Franklin Institute.*

| 1860. | Gettysburg, Adams Co. Lat. 39° 49′ N. Long. 77° 18′ W. Ht. 624 ft. Prof. M. Jacobs, Obs. | | | | Harrisburg, Dauphin Co. 40°16′, N. 76°50′. W. Ht., 300 ft. John Heisely, M.D., Obs. | | | | | Shamokin, Northumberland Co. 40° 45′ N. 76° 30′ W. Height, 700 ft. P. Friel, Obs. | | | | Fleming, Centre Co. 40° 55′ N. 77° 53′ W. Ht., 780 feet. S. Brugger, Obs. | | | | Erie, Erie Co.—Lat. 42° 8′ N. Long. 80° 12′ W. Height about 640 feet. Benjamin Grant, Obs. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Oct. | Thermometer. Mean. | Thermometer. Mean daily range. | Rain. | Prevail'g winds. | Barom. Mean. | Thermom. Mean. | Thermom. Mean daily range. | Rain. | Prevail'g winds. | Thermom. Mean. | Thermom. Mean daily range. | Rain. | Prevail'g winds. | Thermom. Mean. | Thermom. Mean daily range. | Rain. | Prevail'g winds. | Barom. Mean. | Thermom. Mean. | Thermom. Mean daily range. | Force of Vapor. 2 P. M. | Relative humidity. 2 P. M. | Rain. | Prevail'g winds. |
| | ° | ° | Inch. | Direc. | Inch. | ° | ° | Inch. | Direc. | ° | ° | Inch. | Direc | ° | ° | Inch | Direc. | Inch. | ° | ° | Inch. | Per ct. | Inch. | Direc. |
| 1 | 49·7 | 3·3 | 0·641 | N W. | 29·912 | 52·7 | 4·0 | 0·577 | E. | 48·0 | 2·0 | 0·250 | S E. | 51·7 | 6·7 | 0 600 | S W. | 29·337 | 59·7 | 11·0 | ·459 | 83 | 0·550 | S W. |
| 2 | 66·0 | 16·3 | 0 095 | S W. | 29·829 | 68·0 | 15·3 | | S W. | 67·3 | 19·3 | | W. | 43·0 | 11·7 | | (var.) | 29·412 | 60·7 | 2·3 | ·481 | 78 | 0·150 | N W. |
| 3 | 61·3 | 4·7 | | E. | 29·964 | 64·0 | 5·3 | | S W. | 62·0 | 5·3 | | E. | 56·0 | 7·0 | | S W. | 29·483 | 60·7 | 0·7 | ·449 | 73 | | E. |
| 4 | 60·0 | 5·3 | | S S W. | 29 875 | 63·0 | 2·3 | | S E. | 58·0 | 8·0 | 0·030 | E. | 63·7 | 9·7 | | (var.) | 29·324 | 65·3 | 4·7 | ·576 | 84 | 1·110 | W. |
| 5 | 66·7 | 6·7 | | (var.) | 29 741 | 67·3 | 4·3 | | (var.) | 64·0 | 6·0 | | E. | 63·7 | 6·0 | | N W. | 29 369 | 63·3 | 2 0 | ·576 | 84 | 0·069 | N. |
| ☾ 6 | 53 3 | 13·3 | | N N W | 29·845 | 56·3 | 11·0 | | N. | 49·3 | 14·7 | | W. | 49·0 | 14·0 | | N E. | 29·482 | 52·7 | 10·7 | ·364 | 70 | | E. |
| 7 | 49 0 | 11·0 | 0·320 | (var.) | 29·701 | 52·7 | 8·3 | 0·586 | (var.) | 49·0 | 14·3 | | E. | 50·3 | 13·3 | 0·455 | W. | 29·115 | 58·7 | 9·3 | ·404 | 63 | 0·950 | (var.) |
| 8 | 60·0 | 11·0 | | (var.) | 29·245 | 63·3 | 10·7 | | N W. | 59·3 | 10·3 | 0·588 | (var.) | 58·0 | 11·0 | | N W. | 28·946 | 54·0 | 16·0 | ·267 | 66 | | N. |
| 9 | 49·7 | 7·0 | | N W. | 29·436 | 54·3 | 9·0 | | W. | 49·0 | 10·3 | | (var.) | 48·7 | 9·3 | | N W. | 29·075 | 50·3 | 7·0 | ·218 | 58 | 0·110 | N. |
| 10 | 54·7 | 8 3 | | S W. | 29·525 | 60·0 | 6·3 | | S W. | 52·0 | 5·0 | | (var.) | 55·3 | 8·0 | | W. | 28·974 | 58·3 | 8·0 | ·414 | 72 | | S W. |
| 11 | 57·3 | 4 0 | | S. | 29·530 | 60·0 | 5·3 | | S W. | 58·3 | 9 0 | 0·100 | (var.) | 51·0 | 11·0 | | W. | 29·459 | 49·7 | 12·7 | ·207 | 57 | | N W. |
| 12 | 45·0 | 13·0 | | (var.) | 29·822 | 50·7 | 9·3 | | N W. | 45·3 | 13·0 | | W. | 42·0 | 10·3 | | (var.) | 29·388 | 44·7 | 5·0 | ·162 | 48 | 0·190 | W. |
| 13 | 42·7 | 3·0 | | (var.) | 29·891 | 48·3 | 2·3 | | N W. | 42·7 | 6·0 | | (var.) | 43·0 | 2 3 | | W. | | | | ·293 | 68 | | |
| ● 14 | 41·0 | 8·3 | 0·270 | N E. | 29·922 | 45·7 | 4·7 | 0·410 | N E. | 39·0 | 9·0 | | W. | 44·0 | 1·0 | 0·165 | N E. | | | | | | | |
| 15 | 41·0 | 3·8 | | (var.) | 29·911 | 48·3 | 2·7 | | N W. | 40·7 | 2·3 | 1·135 | W. | 41·7 | 4·3 | 0·050 | W. | | | | | | | |
| 16 | 45·0 | 4 2 | | (var.) | 29·878 | 50·7 | 3·0 | | W. | 47·0 | 9·7 | | W. | 44·0 | 7.7 | | W. | | | | | | | |
| 17 | 45·3 | 2 3 | | N E. | 29·788 | 49·3 | 2·7 | | (var.) | 44·7 | 4·3 | | W. | 42·7 | 10·7 | 0·900 | W. | | | | | | 0·330 | |
| 18 | 55·3 | 10·0 | | (var.) | 29·944 | 55·7 | 6·3 | | N E. | 55·3 | 10·7 | | N E. | 46·0 | 3·3 | | N W. | | | | | | | |
| 19 | 50·3 | 5·0 | | N E. | 29·835 | 53·0 | 4·0 | | N E. | 45·3 | 6·7 | 0·77 | (var.) | 49·7 | 3·7 | | N W. | | | | | | | |
| 20 | 51 0 | 2 0 | 1·603 | N E. | | | | | N E. | 51·3 | 8·7 | | E. | 51·0 | 4·7 | 0·575 | N W. | 29·310 | 54·7 | | ·347 | 80 | | S E. |
| ☽ 21 | 56·3 | 5·3 | | N E. | | | | 1·408 | N E. | 55 7 | 4·3 | 0·660 | S E. | 49 0 | 2·0 | | E. | 29·187 | 58·3 | 4·3 | ·400 | 67 | 0·230 | S. |
| 22 | 55·0 | 2·0 | | ? | 29·743 | 59·0 | | | W. | 56·7 | 2·0 | | (var.) | 53·7 | 8·0 | | S E. | 29·273 | 56 3 | 3·3 | ·349 | 70 | 0·040 | S. |
| 23 | 59·0 | 2·0 | | S W. | 29·653 | 57·7 | 1·3 | | (var.) | 55·3 | 1·7 | | (var.) | 55·3 | 1·7 | 0·150 | (var.) | 29·182 | 54·7 | 1·7 | ·320 | 69 | 0·290 | S. |
| 24 | 55·0 | 2·7 | | S W. | 29·674 | 57·7 | 2·0 | | N W. | 55·0 | 0·3 | | W. | 52·0 | 4·0 | | W. | 29·240 | 54·7 | 0·7 | ·377 | 81 | | W. |
| 25 | 59·0 | 4·0 | | N E. | 29·778 | 56·0 | 3·0 | | N W. | 56·0 | 4·3 | | W. | 50·3 | 7·7 | | (var.) | 29·232 | 59·0 | 5·7 | ·268 | 41 | | S W. |
| 26 | 59·0 | 6·7 | | N. | 29·766 | 58·7 | 2·7 | | (var.) | 56·0 | 1·3 | | E. | 48·0 | 3·0 | | W. | 29·390 | 51·0 | 9·3 | ·293 | 68 | | N. |
| 27 | 47·0 | 8·7 | | N. | 30·011 | 51·7 | 7·0 | | N. | 45·0 | 11·0 | | (var.) | 43·0 | 8·3 | | (var.) | 29·475 | 52·3 | 8 0 | ·334 | 69 | | E. |
| 28 | 54·7 | 4·3 | | S E. | 30·078 | 57·0 | 5·3 | | S E. | 54·3 | 9·3 | | (var.) | 52·3 | 9·3 | | S W. | 29·322 | 63·0 | 10·7 | ·366 | 48 | | S. |
| ○ 29 | 60·3 | 5 7 | | ? | 29 990 | 62·7 | 5·7 | | E. | 60·7 | 6 3 | | E. | 60 7 | 8·3 | 0·180 | S W. | 29·464 | 58·7 | 6·3 | ·351 | 65 | 0·360 | W. |
| 30 | 62·3 | 2·0 | 0·990 | S. | 29·952 | 64·7 | 2·0 | 1·113 | N E. | 62·7 | 2·7 | 0 200 | E. | 63·7 | 3·0 | | S E. | 29·401 | 67·7 | 9 0 | ·639 | 76 | | S. |
| 31 | 64·7 | 2·3 | | (var.) | 29·896 | 68·0 | 3·3 | | (var.) | 65·0 | 2·3 | 0·640 | E. | 64·7 | 1·7 | 0 150 | W. | 29·366 | 66·7 | 1·3 | ·486 | 62 | | S. |
| Means | 57·3 | 6·1 | 3·919 | West. | 29·789 | 55·7 | 5·3 | 4·094 | N 28° W | 53·5 | 7·1 | 4·373 | S 65° E | 51·8 | 6·9 | 3·225 | West. | | | | | | 4·370 | |

# JOURNAL

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## CIVIL ENGINEERING.

For the Journal of the Franklin Institute.

### *Abstract of a Report by Croizette Desnoyers upon that part of the Bourbonnais Railroad between St. Germain-des-Fossès and Roanne, a distance of* 41 *miles.* Translated by J. Bennett.

(Continued from page 15.)

#### Tunnels.

The Roanne branch has two tunnels, the Saint Martin d'Estréaux, 1504 yards long, and the Crozet, 247 yards; the first presented difficulties, owing to the hardness and want of solidity in the rock through which it pierced.

*The Saint Martin d'Estréaux Tunnel.—Character of strata traversed.*—The earth is classed among the red quartz bearing porphyries; at the site of the tunnel, there is a mass of very hard rocks, presenting, some distance from the head, a depression filled with hard gore or decomposed rock: the tunnel is established in this gore a length of 76 to 98 yards only, and the rest of the way it passes through rock, composed of red porphyry of porphyroidal granite, with great crystals of feldspar, and at certain points it passes into a sort of diorite with quartz veins; this rock encountered in shaft 7, and near the outlet of the tunnel, is the hardest of all. Its mass is not compact, and it may be regarded as a combination of huge blocks,

separated by their beds of clay or talc, in which, on making an opening, the blocks lose their equilibrium, sliding, falling, and producing enormous thrusts. To the great hardness and want of solidity of this portion, is attributed the difficulty of the work.

*Mode of execution.*—Works of this importance cannot at a simple inspection be made ready for contract, as the imperfect knowledge of what is to be met with affords no basis for proper plans. At first the shafts and gallery were entrusted to experienced contractors, who acted as overseers, the prices being regulated in parts and afterwards rectified as the advance of the work afforded the means of appreciating its value. After the completion of the gallery, all the principal elements of the work being known, the Orleans Company then took charge of it, and called for bids upon a well defined plan. The work, which was done by the job till the completion of the central gallery, was afterwards continued and finished upon a regular contract.

The mode of execution in the first period of the work, called for strict and detailed memoranda, and so afforded precise notes upon most of the results.

*Shafts.*—The excavations at the approaches were to be made after the tunnel was commenced, so that shafts had to be sunk at the presumed site of the two heads. Intermediate shafts were also indispensable on a distance of 1454 yards first contemplated,* to bring duration of work within reasonable bounds; their number was to be eight, spaced at intervals of 153 yards, except at the heads, which were 197 yards apart, as it was hoped that the approach excavations might be made in time to expedite the works at the ends. The depths of the shafts varied from 23·45 yards to 58·51 yards, and at a mean were 39·30 yards.

The shafts had an interior rectangular section of 4·92 yds. by 2·18 yds., and were divided into three compartments, two for the ascending and descending bins, and one, smaller than the others, for the ladders, pump, and ventilator. They were sheeted the whole height; this measure being indispensable from the frequency of landslides, the instability of the blocks, and the shocks from blasting. The pits were worked by horse-gins, which, with the openings of the pits, were covered by sheds, which sheltered the drainers and the discharging hands; afterwards, a fire-place was made at an angle of each shed, for drying the clothes of the miners. The openings of the compartments were formed of trap-doors, which opened only for the passage of the bins; this precaution prevented accidents.

The mean descent per week, varied from 1·66 yds. (shaft No. 2) to 0·92 yds. (shaft No. 7). The working of the last shaft, with a depth of 52·39 yds., lasted thirteen months.

The mean price per cubic yard of excavation, including drilling of holes, blasting, breaking up of material, raising, depositing, leveling, the finding of powder, lighting, repairs of tools, and fixtures, varied from \$3·80 (shaft 2) to \$9·85 (shaft 7): it was at a mean \$6·31.

* Afterwards carried to 1504 yards.

These prices result from the memoranda, with the addition of ·05 for incidental expenses, and ·1 for profit.

For a zone of 7·63 yards in height, from the bottom of each shaft, the cost per cubic yard was more considerable, rising to \$5·18 (shaft 8), and to \$10·90 (shaft 7); as a mean it was \$8·78.

Here is a table of the sub-details for the least and most hard of the shafts, and for the general mean.

| Nature of Expenses. | Expense per cubic metre of excavation at the lowest part of each shaft. | | |
|---|---|---|---|
| | Shaft 8. | Shaft 7. | Mean. |
| | francs. | francs. | francs. |
| Work of miners, | 7·46 | 20·40 | 17·15 |
| " laborers, | 2 99 | 8 52 | 8·89 |
| " horses and drivers, | 2·66 | 8 19 | 5·54 |
| Powder, | 3·39 | 4·31 | 3 53 |
| Lighting, | 1 05 | 2·49 | 2·12 |
| Different fixtures, | 0 31 | 0 34 | 0 48 |
| Repairing tools, | 10·44 | 15 57 | 10 91 |
| Fuses, | 1·04 | 1 65 | 1·13 |
| Gross, | 29·34 | 61·77 | 49 75 |
| ·05 for incidental, | 1·47 | 3·09 | 2·49 |
| Net cost, | 30·81 | 64 86 | 52·24 |
| ·1 for profit, | 3·08 | 6 49 | 5 22 |
| Contract price, | 33 89 | 71·35 | 57·46 |

NOTE.—1 franc per cubic metre = 15·29 cents per cubic yard.

The cost of sheeting was \$35·28 per yard of depth.

The cost of material for gins, bins, cars, temporary iron railways, cables, ladders, guys, sheds, &c., as paid to the supervisors, was at the rate of \$1600 per shaft; but as during the construction of the tunnel this material was economized, we may set down \$200 as the sum total for each shaft, or say \$5·11 per linear yard.

We may set the cost of draining at \$6·03 per yard.

According to these results, the net cost of shafts per linear metre was at a mean:

| | |
|---|---|
| Excavation 16·6 cub. yds. at \$6·31, | \$105·47 |
| Sheeting, | 35·28 |
| Cost of materials, | 5·11 |
| Drainage, | 6 03 |
| | \$151·89 |

But in reality it rose to \$182·80 per yard, since the price previously agreed upon with the overseers was found to be superior to those resulting to the valuation made during the prosecution of the work.

*The Gallery.*—The gallery was opened with a width of 4·15 yds., and a height of 4·59 yds., or 19 square yards. This section is greater than usually adopted, and the reason was that the miners required nearly the same price for from 12 to 14 yds. in section as for 19·13 yds. There was thus an advantage in adopting this dimension, which notably facilitated the work, without involving any serious inconvenience to the sheeting. But there would have been no advantage in having a larger section, for the experiment was made with one of 23·92 sq. yds., without sensibly diminishing the cost. The gallery was placed at the upper part of the appointed section, and it seems to be a good disposition, when the difficulty of working the upper part in hard rock is considered. The sheeting was dispensed with for about one-half the length; in the other half, they were not required to be very strong, though at some points, especially between shafts 9 and 10, the thrusts were so great that oak pieces, 12 inches square, were broken, and the frames had to be doubled and propped in the middle of their height.

The shafts were placed at 5·45 yds. outside the centre of the tunnel, so that before commencing upon the gallery, small cross-galleries had to be pierced, which have disappeared upon the opening of the tunnel section proper. Communication between pits and gallery was maintained by rail tracks; the trucks carrying the bins were received upon movable platforms, which did away with the need of turntables.

The mean progress of each gallery per week worked upon two faces varied from 4·69 yds. (gallery of shaft 2) to 1·39 yds. (gallery of shaft 7), and in the latter it took over eighteen months to establish a communication with the neighboring shafts; the mean progress of the whole gallery was, for each face, 1·46 yds.

As the faces worked were two for the intermediate and one for the end shafts, in all 18, we see that the general piercing advanced, as a mean, 26·28 yds. only, per week; that the mean volume taken out per week was 19·13 × 26·28, or 502 cub. yds.; and that the mean daily excavation was 72 cub. yds.

At each face there was a force of 5 miners, who worked for 10 hours, and were then relieved by another similar gang; in 100 hours about 3·92 cub. yds. were taken out. Each miner in 10 hours drilled nearly 3 holes, 15¾ ins. deep, so that each cub. yd. required 8 holes. The mean price per cub. yd., including the same manœuvring and equipments as the shafts, with the addition of incidentals and profit, varied from $3·63 (gallery of pit 2) to $12·62 (pit 7), and was at a mean $6·27.

As respects the hardness, the galleries may be divided into two classes: the first containing the galleries of the ends, corresponding to pits 1, 2, 8, 9, and 10; the second, with the central core, answering to pits 3, 4, 5, 6, and 7, in which the price attained the highest rate.

Here is a table of sub-details resulting from the valuation of expenses, which, being taken as a mean, have more value than extremes, which may present anomalies.

| Nature of Expenses. | Cost per cubic metre in gallery. | | |
|---|---|---|---|
| | Mean for galleries of shafts 1, 2, 8, 9, 10. | Mean for galleries of shafts 3. 4 5, 6, 7. | General mean of shafts. |
| | francs. | francs. | francs. |
| Work of miners, | 9·10 | 21 24 | 15 17 |
| " laborers, | 2 87 | 4·71 | 3 79 |
| " horses and drivers, | 2·26 | 3 70 | 2 98 |
| Furnishing powder, | 2·20 | 4·48 | 3·34 |
| " fuse, | 1·03 | 2·10 | 1·56 |
| Lighting, | 1·11 | 2 29 | 1·70 |
| Various fixtures, | 0·21 | 0·43 | 0 32 |
| Repairs of tools, | 5·27 | 8 01 | 6·64 |
| Gross cost, | 24·05 | 46·96 | 35 50 |
| ·05 for incidental, | 1·20 | 2·35 | 1·78 |
| Net cost, | 25·25 | 49 31 | 37·28 |
| ·1 for profit, | 2·53 | 4 93 | 3 73 |
| Contract price, | 27·78 | 54·24 | 41·01 |

Note.—1 franc per cubic metre = 15·29 cents per cubic yard.

The mean cost of galleries (41·01 francs), or \$6·27 per yard, is nearly the same as that of the shafts (41·29 francs), or \$6·31 per cubic yard; but, in reality, it is only with the lower portion of the shafts that the comparison should be made; now the price for this lower part is \$7·78 per cubic yard, and, consequently, the gallery excavation has cost ·714 of that of the corresponding part of the pits.

The above table enables us to reckon the number of days, the quantity of powder, of fuse, the number of points of tools, and all the principal elements of work per cubic yard.

Thus, the wages of miners being 90 cents, we see that 3·37 days per cubic metre, or 2·58 days, were required per cubic yard.

The price of powder being 2·25 francs the kilogramme (20·4 cents the lb.) the quantity per cubic metre was at a mean, 2·52 lbs. per cubic yard, and as we have seen that there were eight holes per cubic yard (10, per cubic metre), it follows that the charge for each hole was 0·33 lb. The miners generally reckoned 2·2 lbs. for 7 blasts.

At the rate of 1·83 cents per yard (0·10 francs the metre) the length of fuse was 13 yards per cubic yard, say 1·61 yards per hole.

The repairs of tools consisted mainly of re-pointing the drills; each point costing 2 cents; there were required 50 per cubic yard (66 per cubic metre), or 7 for each hole. But in the hardest galleries the quantity was greater; thus, for shaft 7 there were used 15 points per hole,

and, especially at the commencement, after a few strokes the drill would get dull and have to be replaced.

Referring to a period of 24 hours for the different elements of work for the whole tunnel, we find for an advance of 3·75 yards, and consequently for the excavation of 72 cubic yards, there were required 180 days of miners, 181 lbs. of powder, 90·5 yards of fuse, and 4000 points of drills.

For delivery and loading excavation, raising in bins, and depositing it, there was required 1·14 days of laborers per cubic yard (1·5 per cubic metre) and 0·37 days of horses, or say in 24 hours for the whole tunnel 82 days work of laborers and 27 of horses. For the period of 24 hours, answering to 20 hours of effective labor, 3 horses were used for most of the shafts, and two only for those which yielded the least. The horses were very strong, since the loads raised were heavy; but they rested often, since the quantity per day was small, and this sufficiently accounts for not using a steam engine.

The cost of drainage was at a mean $36·00 per day, and $9·69 per yard of gallery.

The expense of material may be set at $4·02 per running yard.

The cost of sheeting the galleries was $12·24 per linear yard for the whole tunnel, and $24·31 for the parts actually requiring it.

From these results the actual net cost per linear yard should be, as a mean:

| | |
|---|---|
| Excavation 19·13 cubic yards at $6·27, | $ 119·94 |
| Sheeting, | 12·24 |
| Draining, | 9·69 |
| Materials, | 4·02 |
| Total, | $ 145·89 |

The cost was greater, in fact, because for a length of 240 yards the section of the gallery was 23·92 yards, and because the overseers had at first too high a price, which was afterwards rectified when a more exact basis was attained.

*Upper breastwork.*—On the completion of the gallery the upper section of the breast (the bottom of which was at the same level with that of gallery) was commenced. In the most solid parts there was no sheeting and for remainder of tunnel, sometimes it was sufficient to support a part of the crown; then again the whole surface had to be supported by fan-shaped struts covered with joists. Care was taken to have it well sheeted in all parts and wherever the ground was not of undoubted solidity the breastwork was carried on by short advances just enough to provide room for the masonry constructed immediately after the excavation.

For the first part of the work regular notes were taken, showing the cost as $4·40 per cubic yard. After trials proved that this price agreed well with the general mean.

The section varied from 10·75 to 16·75 square yards, according to the thickness of the lining, and at a mean stood at 13·75 yards.

The expense of sheeting is not given as it fell within the regular

contract of the second period; as the same planks served for a great number of rings, and as the arrangement of the struts was so variable that their contents could not be appreciated. It is simply stated that the expense was inconsiderable, that the work was made with sheeting of the gallery, and so required no new equipment.

*Lower breast section.*—The remaining section of the tunnel (called *strauss*) was mostly excavated after the construction of the arch. It was only in the solid portions that the entire section could be safely opened before the lining of the arch, and it is perhaps best in no case to do it, even though there were no concussions or injuries to be apprehended from the blastings. These evils were much less than anticipated; by covering the blasts with fagots the fragments of rock were sufficiently kept from the arches, and there were but few exceptions where the bricks were injured or had to be replaced.

The excavation of the lower section was valued at $4·18 in the hardest part of the tunnel, and at $2·80 in the other part, and at $3·49 at a mean. Experiments made during the construction have shown that the cost should not have exceeded $2·75 per yard.

The section (strauss) to which this price refers, varied from 28·75 to 32·7 square yards, according as the piers were or were not lined, and as a mean was 30·75 square yards.

Thus the cost of excavation of the shaft $7·78 was reduced to $6·27 for the header, $4·40 for the upper, and $2·75 for the lower breast; which, reckoning the surface of each part of the tunnel, gives $4·29 for the mean cost of the whole section. The general section varies from 56 to 64 yards, with some exceptions. The mean section amounts to 61 yards.

*Arches.*—The interior section of the tunnel is a portion of an ellipse with its centre 6·43 feet above the base (answering to 4·26 feet above the rails), and whose semi-axes are respectively 15·08 and 12·63 feet. With these dimensions the width at the level of the rails is 24·27 and the height above the exterior rail is 15·74 feet. Upon the continuous elliptic surface, the arch answers to that part situated 13·12 feet each side of the key, having thus a development of 26·24 feet. This portion was constructed either of bricks or rubble masonry. All the remainder, regarded as piers, was made of rough rubble obtained from the excavation.

The thickness of the arch is quite variable. According to the plan the arch was to have been entirely constructed of brick, with a thickness of 1·15 feet or $1\frac{1}{2}$ bricks for one section, and 1·97 feet or $2\frac{1}{2}$ bricks for the other. But on constructing, it became necessary to increase the thickness at points of great pressure, and in some cases to substitute granite rubble for the brick; on the other hand, in the solid parts the lining was of no other use but to keep the rock from the action of the air, and might be reduced to the simple length of a brick or 9 ins.; the normal sections have thus conformed to Figs. 3 and 4, Plate II, saving that sometimes intermediate thicknesses of $1\frac{1}{2}$ or 2 bricks have been adopted, and sometimes in the heaviest loaded portions, rubble work with well dressed beds has been laid in thicknesses varying from

2·3 to 3·3 feet. The mean thickness is about that of the plan 1·56 feet; while the dimensions at the different points conformed to the necessities of the case revealed by experience.

In the solid parts where the arch was constructed after the excavation of the lower breast, the centres were easily moved on rollers, which could not be done in the upper breast on account of the uneven level at the bottom of the header.

The arch was constructed at a maximum in lengths of 13 ft., being reduced in difficult parts at least to 6½ ft.

*Piers.*—The part of the piers between the bottom of the gallery and the arch proper, was constructed at the same time with the arch. On making the plan, there was a hope of dispensing with the construction of piers upon one-half the tunnel; but it was impossible, at least for the part above base of header, on account of the difficulty of cutting the rock, so as to be a prolongation of the curve of the arch.

The same difficulty was found in cutting the batter of the lower section, both from the interior rents caused by the blasts, and because the upper surface was too inclined to support the masonry in safety. So that, in reality, although the rock was solid enough to require no lining for over a half of the length, yet it was not dispensed with for more than a quarter.

The underpinning was executed in lengths of from 6·5 to 13 feet. When the earth was quite solid, strutting was not used; when of a medium solidity, the masonry already built was shored, and a simple inclined brace put up; when of an inferior solidity, a thorough system of strutting was adopted, and sometimes shores were placed between the principal brace and the abutment of the opposite side.

*Gutters and Aqueduct.*—At the level of the springing of the arch, throughout the length of the tunnel, small gutters were made, with alternate slopes, abutting at intervals of 164 feet upon cement pipes, which conveyed the water to the central aqueduct, made in the middle of base of tunnel. This aqueduct, besides the water from these pipes, received that of the bottom, from the small outlets prepared for that purpose.

*Closing of shafts.*—There were four shafts, Nos. 3, 5, 6, and 8, retained for the ventilation of the tunnel. Their distance apart at the centre was 152½ yards, but was increased towards the heads. They were lined with masonry of an elliptic section, Figs. 5, 6, and 7, Plate II.; but as the masonry occupied but a portion of the void which had to be filled, it was strengthened by a buttress alongside of filling. The bottom of the shafts served as sidings for track repairers. Other sidings were reserved at intervals of 76 yards throughout the tunnel.

For the suppressed shafts, a filling of the whole height would probably have thrust out the abutment of the arch; there was therefore made at the base, two small discharge arches, which were filled with rubble, and covered to a certain height with rubble, which supported the upper filling; the water drainage was carefully provided for, and a siding left at the bottom.

The heads of the tunnel are very simple, supporting a tablet giving

the length, height, and dates of construction. That on the Saint Germain side is of beautiful gray granite, and that on the Roanne is of Chevroche limestone. In the latter, the counterforts resist the great exterior thrust, and serve to amend the unpleasing effect arising from the different inclinations of the slopes of the excavation.

*General expense.*—

| | |
|---|---|
| The expenditure during the first period of the works for shafts, galleries, and the commencement of breast, was . . | \$332,493 00 |
| The completion of the work was contracted for at the rate of \$241·29·6 per running yard for 1476·36 yds. of length first adopted, | 356,400 00 |
| But as the tunnel was lengthened 32·81 yds., there is an addition at the rate of \$365·60 per yard, . . | 12,000 00 |
| Finally, the cost of contingencies for supervision and for various fixtures, amounts to . . . | 18,000 00 |
| | \$718,893 00 |

Or, in round numbers, for a length of 1509 yards, \$476 per linear yard.

The shafts and heads appear in the expenses with the sum total of \$74,000, or \$50·35 per linear yard. The net cost of the tunnel proper may be thus set at \$426 per running yard.

A careful study of the work proved that, notwithstanding the real difficulties of execution, this price was too high by about \$36·56, due to the two above-named causes.

At first, the mode employed for the construction of the shafts and header caused the overseers to undertake the work at a high profit, and it was for their interest that the results of the valuation, as data for the contract, should reach as high a figure as possible. The first period of the work has, therefore, cost too much.

In the second place, the negotiations between the state and company for the transfer of the work, occasioned the loss of five or six precious months in the season of 1855, and the consequence was, that between the tenders made (one at the commencement of negotiations, the other at the end,) by the contractors, there was a difference of \$21·93 per linear yard.

The engineer here submits a table of what he considers to be a fair price for a tunnel in similar conditions with the Saint Martin. Without giving the details, the general cost per linear yard of full section for very hard and solid porphyretic rock, of the type of (Fig. 3, Plate II.) was \$402·16; for hard, but not solid, porphyretic rock, type of (Fig. 4, Plate II.) was \$393.

The expense does not differ much, because the increased masonry compensates very nearly in the second case for the decrease of hardness in rock.

Supposing that the shafts were of the same depth and in the same conditions as at St. Martin, the total cost per yard would be \$438·72.

*Time of execution.*—The first shaft was commenced in November, 1852, and the others shortly afterwards, so that they were finished at

nearly the same time; the first part of the work lasted a year. The driving the headers lasted another year, excepting that of shaft 7, which required more time, but d'd not prevent the breastwork and masonry upon the remainder of the length. At this time (Feb., 1855), the tunnel was to have been put out at contract in behalf of the state, but the negotiations with the company prevented this measure, and up to the month of the following July, nothing was done. The works were then let by the company, July 6, 1855, and since then were conducted with great activity. This last period, including the construction of arches, the underpinning of piers, and accessory works, lasted two years; so that, in reality, the locomotives passed through the tunnel in November, 1857, five years after the commencement of the first shaft, but with four years and a half only of effective work.

According with the basis of a mean progress of 4·39 feet per week upon each face, if the tunnel had been worked solely from the heads, it would have taken ten years, on the supposition that the cuts were previously made. In consideration of this fact, the dispositions adopted at the beginning of the work should not be regretted.

*Accidents during the construction; landslide between shafts* 8 *and* 9.—Some time after the opening of the gallery between shafts 8 and 9, in a portion which seemed solid, and which therefore had not been sheeted, a serious slip occurred. It extended in length about 44 yards, and in height 26 feet above top of gallery. In the upper part, the direction of the void was oblique. The surfaces were very smooth, and covered with a light bed of clay; the position of the faults, and the presence of this clay, occasioned the sliding of the blocks, which were of enormous size, having in some cases tables of porphyry 8·74 yds. by 9·84 yds. by 1·53 yds., containing 131 cubic yards. To prevent the spread of this movement, the gallery was hastily and strongly sheeted at the ends of the slide, and in the slide itself braces were placed, sustaining many parts of rocks whose fall was imminent.

The repair was a difficult matter, for a portion of the rocks remaining in place was full of fissures; others appeared on the verge of sliding, and were only held up by the sliding mass. There were fears in taking away these blocks of creating fresh movement in the upper part; the blocks, on account of their size and hardness, could not be taken away except when divided by blasting, and the resulting shocks might detach new portions of the rock, and aggravate the evil. In this dilemma, recourse was had to the following method, proposed by M. Simon Trône, one of the contractors for the second period of the work, which was executed by him with true skill.

A commencement was made in circumscribing the landslide, by pushing forward as far as possible on both sides, the construction of the arches, so that, before attacking the slide proper, the length between the constructed arch was reduced to 30 yards. If the attempt had been made to directly re-establish the gallery by attacking the lower part of the slide, even with the help of strong sheeting, it is quite likely that the whole mass, as well as a great part of the rock then in place, would have been precipitated. They therefore sought to effect

a way through the upper part, dividing it by slight blastings, and by carefully taking away in parts the blocks forming the summit of the slide; so that a slight advance being made, a wooden frame conforming with the void was hastily erected, and strongly supported upon this were stringers sustaining the rock, which were urged forward as far as possible, when the excavation began for the raising of another frame, and so on till the date of April 25, 1856, when the consolidation of the upper part, and a communication above the slide was effected between the two portions of the gallery on either side of it.

From this time confidence was restored, and the second period of repair closed with the removal of the lower part of the fallen mass, and the construction of the masonry. Passing over the details, suffice it to say, that the arch was made of granite rubble, with well dressed beds; that a thickness of 3 feet was given to the masonry, and care was taken to fill the upper void of the slide with dry masonry laid as close as possible; and at the closing of the last ring, a discharging arch was thrown over the dry masonry, in which a man could work till the last moment, and which served for as solid a filling in as that given to the adjoining rings.

The work of passing through the slide lasted over six months.

At different periods of the construction of the tunnel, especially upon the breastwork, there were several other slides, but of less importance than that just described.

*Slide between shafts 9 and 10.*—In the underpinning for the construction of the piers, an accident of another kind occurred between shafts 9 and 10, worthy of notice. In this part, the rock formed a compact mass on one side of the tunnel, but on the other presented numerous faults filled with clay; these faults were nearly parallel, and much inclined towards the centre of the tunnel. The arch had been constructed carefully and completed without accident; but in resuming the underpinning, after having constructed several lengths of piers, too many of the intervals were worked at one time, and a movement took place, which thrust the arch inwards; some of the voussoirs were broken, but the arch did not fall and continued to present a regular curve. At the origin of the slide, the displacement at the springing line was very little, attained 16 ins. about half way, was 8 ins. at five-sixths, and ended a few yards beyond this. The portions of piers already constructed were pushed inwards the same as the arch. This movement extended 38 yards.

They commenced by replacing the arch upon its centre at the two ends, and by an immediate reconstruction of the altered part, wherever the pier had not been worked. In the part already excavated, the deformed side of the arch was strongly shored against the sound side of same, and braces being put under the projecting angle, the pier was constructed in its true position. The parts of the neighboring piers which had been moved were also rebuilt; then the displaced portion of the arch was demolished, and rebuilt in its true place. Portions of inverted arches were also constructed to prevent any future movement of the piers. After the repairs not the slightest movement has been detected.

*The Crozet Tunnel.*—The Crozet tunnel pierces a spur near the Pacaudière, and its summit is 31½ yards above the road bed. The ground traversed presents in the centre a core of granite, covered on either side by a mass of hard gore. The tunnel being but 247·4 yds. long, was worked from the two heads, and this, with the difference of hardness, rendered the execution much less expensive than the St. Martin d'Estréaux tunnel.

The interior section is the same as the St. Martin; but the lining is complete for the whole length, even for the piers, and the thickness of masonry is greater; the arrangement of the gallery and the mode of sheeting are the same. Owing to the inconsiderable depth of earth, its character was easily ascertained by soundings, which cost about $2·19 per linear yd., for soft and hard gore, until it struck the rock.

*Expense.*—There were two prices, one for granite, the other for common earth. Passing by the details, the general price per linear yard (full section) in granite, was $288·82; for common earth, $200·71: as a mean, $244·76.

Observations made during the work show that the estimate was sufficient for the portion in rock, but not so for that in earth, and that the mean price should have been $254·92.

On comparing the price of the rock part of the Crozet tunnel with the least hard half of the St. Martin, we are struck with the difference $288 and $393, for the hardness was about the same in each. This difference arises mostly from the different modes of working, one from the heads, the other through shafts. The cost of raising the excavation at St. Martin caused an increase of from 46 to 61 cts. per cubic yard, or say from $27 to $36½ per linear yard of the whole section. The masonry of St. Martin made an increase of $16·51, or ·2 of the expense, due to the passage of materials through the shaft. The cost of drainage was, of course, much less at Crozet, since, during the greater part of the work, the water was passed through at the heads without special provision for it. The difference in the mode of working has diminished the net cost from $81 to $91; if to this we add the suppression of the shafts, say $45¾, we see that the same tunnel which, constructed by shafts at a cost of $438 per yard, would not cost over from $310 to $329, if the whole had been worked from the heads. This is a grave consideration, which, though disregarded when pressed for time, should yet prompt us on works of long duration to begin early with tunnels of a certain extent, so as to realize a saving of one-quarter the expense.

| | | For very hard and solid porphyritic rocks, type fig. 0. | For hard porphyry but not solid, type fig. 0. |
|---|---|---|---|
| COST PER CUBIC YARD.— | Gallery, . | $8·25 | $4·28 |
| | Upper breast, | 5·50 | 3·06 |
| | Lower " . | 3·36 | 2·14 |
| | Brick masonry, | 7·64 | 7·64 |
| | Rubble " . | 5·35 | 5·35 |
| | Dry Stone " | 3·06 | 3·06 |

*Retaining walls at Crozet.*—Just before arriving at the Pacaudiére station, the railroad cuts the foot of a steep hill, upon the summit of

which stands an old tower, and a great number of houses, forming the village of Crozet. The usual slope of 45°, would extend throughout the whole height of the hill, and tend to undermine the foundations of the tower. Moreover, on the upper part, were some boulders, while on the lower part of the hill, that to be excavated, was a clayey gore of bad quality. Some mode of consolidation had to be devised, and a prompt one, to guard safely against the fall of the tower and houses. A retaining wall was planned; only instead of giving it a uniform thickness, it was composed of circular parts, 19·7 feet long, stayed by counterforts $6\frac{1}{2}$ feet thick. The earth at the upper part was to have been cut along the line M N, Fig. 8, Plate II.; but in the course of the execution, numerous slides occurred, causing great difficulty in the foundations of the walls, and some alarm for the preservation of the houses on the hill, so that the final slope took the form indicated by the broken line O P Q N: the space between the slope and wall was filled with rubble, and this consolidation sufficed to arrest all movement, without the necessity of resuming the projected slope along M N.

The thickness of a wall should be proportionate to the difficulties of its position and the chance of damage from accidents; but aside of this, the adopted arrangement is thought preferable to a wall with a uniform profile; first, because that one of the components of thrust produced upon each intermediate portion is destroyed at the axis of the counterfort, by the similar component of the adjoining section; and, secondly, because the counterforts present solid supports, and in case of accident prevent the movement from spreading, as with walls of a constant thickness. It is thought that a given volume of masonry can be more usefully employed with this form than with that usually adopted.

*Water passages of the Sigaud's bridge.*—It is often useful for the settlement of damages, to preserve for proprietors their water rights on either side of the road. When cast iron bridges are constructed over a cutting, the preservation of water passages may be had with but little increased cost, by using beams of a rectangular section, conformably to that given in Fig. 9, Plate II., for a bridge 41 feet span. To clean out the small channels thus formed, longitudinal openings, like those shown upon the plan, Fig. 10, Plate II., are made in the top of the beams, through which is introduced a small spade, which by turning round at right angles may clear the whole section of the beam.

*Culverts $6\frac{1}{2}$ feet span.*—Culverts of $6\frac{1}{2}$ ft. span were constructed under banks from 65 to 82 ft. high, and it was important to give them a form best fitted to resist this great load. An elliptic section was accordingly adopted, Figs. 11 and 12, Plate II. When the foundation has but little depth, the bottom of the ellipse is intersected by an inverted arch; but when it is deep, the ellipse is complete, except when a false invert is made for the passage of men or cattle. The two sections of these culverts, with the dimensions adopted in building, are given, because there is a general scarcity of types of such works

under great embankments, and because, at the same time, if experience has proved that the dimensions adopted upon their line were sufficient for solidity, it has also shown that these were not far from the limit, and that the want of proper precautions has occasioned many accidents.

Instead of constructing the culverts in the lowest part of the valley where the solid earth has usually a great depth, great care was taken to place them upon the side, as shown in Fig. 13, Plate II. By this, expensive foundations were avoided, the length between the heads reduced, and in undulating ground, the water did not become stagnant above, when advantage was taken of the difference of slope existing between the upper and lower footing of a high bank, which always has a wide base.

The culvert being constructed, great precautions are to be taken with the covering of the bank, to avoid any displacement. On this account the dumping should be stopped a little in front of the culvert, the earth to be taken in barrows, and laid on in thin well rammed layers, first upon the lowest side, and then upon the other, so as to envelope the culvert with a mass of earth indicated by the dotted line, *a b c*. When the bank has reached a height of several yards, then it may be advanced by dumping the earth from its summit. This precaution was not always sufficient; for three culverts, which had been covered by barrows a height of from 23 to 26 feet, experienced a slight displacement, manifested in the opening of some joints; another culvert, the Bertalière, which had a cover of 10 feet of earth, whose masonry had been constructed in a far advanced season, was deformed in the arch, and the masonry in the upper part was displaced from 3 to 4 inches.

Another kind of movement was produced in the Closdit culvert, but more difficult of explanation; it was found separated in two parts at the middle, by a section a little oblique to the axis. The separation might have been easily explained by a settlement, had not the two parts been found to be at the same level; but the least difference in height could not be detected, nor the least departure from a true range, either in the arch or invert. As the rupture is nearly at the centre of the culvert, it is probable that the weight of the bank caused the middle to settle more than the ends, and may thus have caused the disjunction, though the curve which the key in this case would naturally take from head to head was wholly imperceptible.

*Accident at the Roudillon Bridge.*—A more serious accident occurred during the construction of the Roudillon bridge. This work, of the type most frequently used in excavation, is formed by an elliptic curve 40·8 ft. span, 11·5 ft. rise, resting upon abutments 5¼ ft. high. The heads are of cut stone granite, and the intrados of rubble granite blocks, with 1·1 ft. tailing. In taking down the centering, the heads settled from ·6 to ·8 in., and the joints at the extrados slightly opened at *a b c*, *a′ b′ c′*, Fig. 14, Plate II. This movement, though too much for an arch of this span, did not excite any alarm; but it was much greater at the rubble intrados, which at the centre was lowered from

3 to 4 inches, and thrust outwards the bottom of the head voussoirs ·8 inch; in this movement the voussoirs were detached from the rough rubble, which completed the thickness of the arch, leaving an interval of 1·6 inches; at the same time the joints were opened upon the upper surface, a necessary consequence of the thrust exerted upon the heads, and the displacement produced by it.

The arch was entirely torn down, and rebuilt. The contractor laid the accident to a want of sufficient height in the spandrils, to resist the thrust to be expected in the taking down of centering. This may explain the unusual settling of the heads, but not the difference existing between it and the rubble blocks. The accident is really due, 1st, to the too great uniformity in length of tailing of the blocks; 2d, to bad masonry and insufficient care in bonding the intrados blocks with the coarse rubble upon it; 3d, to bad mortar, made of a somewhat earthy sand; 4th, to inequalities, and too much haste in uncentering.

This accident again proves, that the construction of all these works, even of current dimensions, demands a careful watch at all times. It shows particularly how important it is in the construction of arches, to bond the intrados stones with the masonry forming the complement of the thickness of the key.

*Iron Hand-railings.*—Upon most of the works, with the exception of the great viaducts, a hand-railing, represented in Figs. 15 and 16, Plate II., was used. The uprights and rails were of T iron, which with small weight presents great resistance in both directions. The cross-bars are flat, and are riveted to each other and to the principal pieces. The railing of this type weighs, according to the distance of the posts, 36 to 40 lbs. per lineal yard, or nearly one-half of the common railing in full iron. The price varies from 9 to 11 cts. per lb., so that the mean cost per yard is $3·84. It has a pleasing effect upon the eye, and is cheap.

| | | |
|---|---|---|
| The bridges, culverts, and aqueducts are in number, | 123 | |
| " over the tracks | 17 | |
| " under " | 16 | |
| Their cost per mile—1st section, | | $7,264 |
| 2d " | | 16,718 |
| 3d " | | 6,297 |
| Mean cost per mile, | | $10,093 |

SUMMARY OF EXPENSES.

| *Mean cost per mile.* | |
|---|---|
| General expenses, | $2,442 |
| Purchase of land, | 8,549 |
| Earthworks and accessories, | 35,092 |
| Roads and drift-ways, | 1,841 |
| Great works of art, | 30,121 |
| Various works of art, | 10,663 |
| Stations, | 4,005 |
| Guard houses, &c., | 1,074 |
| Total, | $93,787 |

| | |
|---|---|
| The estimated cost was | $3,800,000 |
| The actual " | 3,840,000 |

I am indebted to John Houston, Esq., Engineer of Bergen Tunnel, for the following account:

*Engineer's Office, Bergen Tunnel,* 1*st December*, 1860.

JOSEPH BENNETT, ESQ.

Dear Sir:—Bergen Tunnel was commenced in 1855, and prosecuted for some eighteen months, when the work was suspended on account of financial difficulties, and was not resumed until February, 1859, at which time I first became engaged on it. Before the work suspended, all the shafts (eight in number) had been sunk, the heading, with the exception of 168 feet, had been driven, and about 900 feet of the bottom taken out.

The tunnel is 4200 feet long, and has a sectional area of 580 feet, or about 21½ cubic yards per lineal foot. The extreme height is 23 feet, extreme width 28 feet. As there was such a small amount of heading to drive after I became connected with the work, and as that was in detached pieces, I had not much opportunity to find out the accurate cost; but the following figures may be relied on as nearly correct. The amount taken out as heading was four cubic yards per lineal foot, and our gangs drove about one foot per day of 24 hours. The expense in the 24 hours was as follows:

| | | |
|---|---|---|
| 24 miners at $1·37½, | = | $33·00 |
| 2 foremen at $2·00, | = | 4·00 |
| 4 laborers at $1·12½, | = | 4·50 |
| 2 tool-boys at 75 cents, | = | 1·50 |
| ½ keg powder at $3·75, | = | 1·87½ |
| 50 feet fuse at $4 per M, | = | ·20 |
| Lights, | = | ·50 |
| Steel, say 5 lbs. at 15c. | = | ·75 |
| Expenses per day, | | $46·32½ |
| 4 cubic yards at $11·58, | = | $46·32 |
| Cost of heading per cubic yard, | | $11·58 |

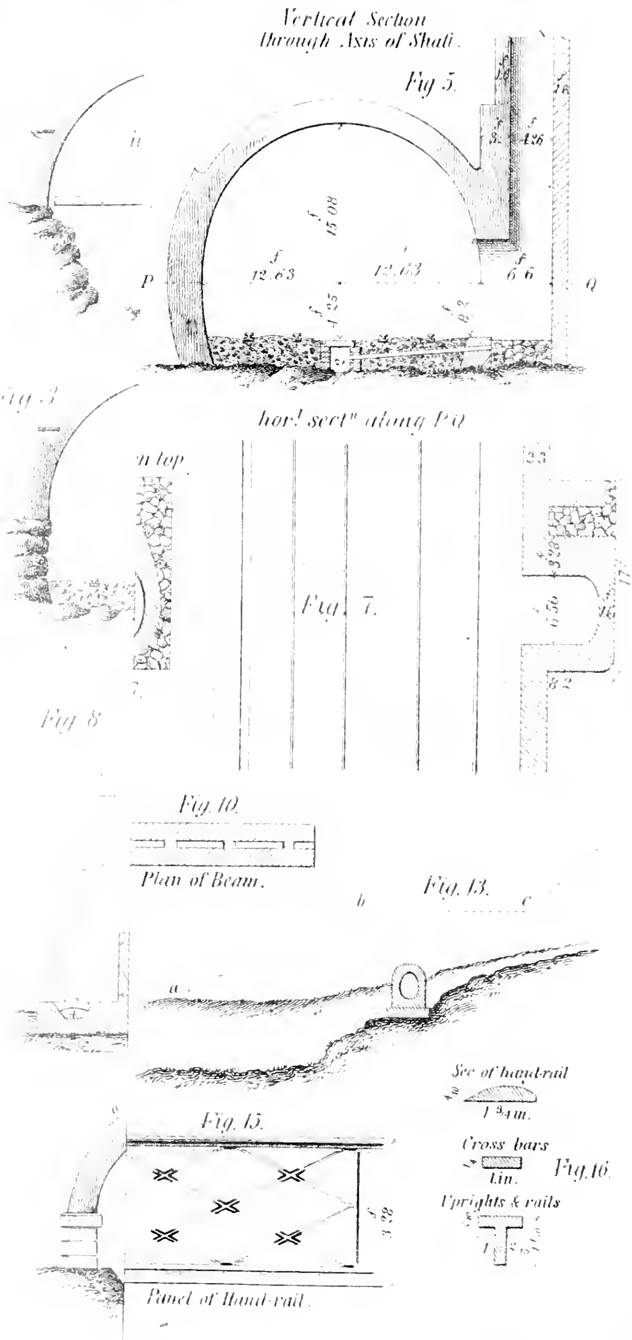
The bottom or breast-work in the shafts, which were worked to the best advantage, cost as follows:

*Expenses under ground on one breast, each* 24 *hours.*

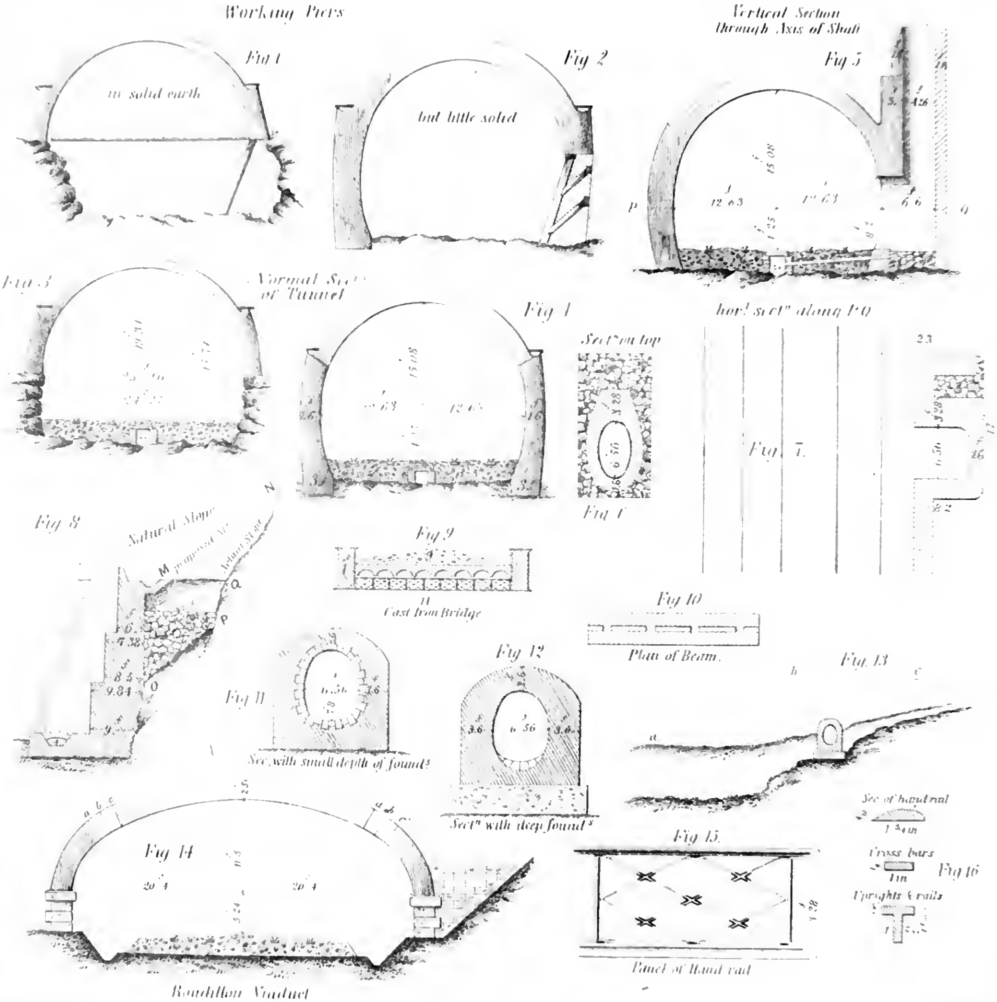
| | | |
|---|---|---|
| 30 miners at $1·25, | = | $37·50 |
| 14 laborers at $1·12½, | = | 15·75 |
| 2 foremen at $2·00, | = | 4·00 |
| 2 blacksmiths at $1·37½, | = | 2·75 |
| 2 helpers at $1·00, | = | 2·00 |
| 2 tool-boys at 75c., | = | 1·50 |
| 2 kegs powder at $3 75, | = | 7·00 |
| 100 feet fuse at $4·00 per M., | = | ·40 |
| 25 lbs. steel at 15c., | = | 3·75 |
| 1½ gallons oil for light at 60c., | = | ·90 |
| | | $75·55 |

*Expenses on top for* 24 *hours.*

| | | |
|---|---|---|
| 4 top-men at $1·00, | = | $4·00 |
| 2 engineers at $1·50, | = | 3·00 |
| 2 firemen at $1·00, | = | 2·00 |
| Oil, | | ·20 |
| Coal for engine and blacksmiths, nearly 2 tons at $5, say, | | 9·00 |
| | | $18 20 |




P S Duval & Son lith Phil.


Working Piers
Fig 1
in solid earth
Fig 2
but little solid
Vertical Section through Axis of Shaft
Fig 5
Fig 3
Normal Sect. of Tunnel
Fig 4
Sect. on top
hor. sect. along PQ
Fig 7.
Fig 6
Fig 8
Natural Slope
Fig 9
Cast Iron Bridge
Fig 10
Plan of Beam.
Fig 11
Sec. with small depth of found.
Fig 12
Sect. with deep found.
Fig 13
Fig 14
Boudillon Viaduct
Fig 15
Panel of Hand rail
Sec. of hand rail
Cross bars
Fig 16
Uprights & rails

| | |
|---|---|
| Amount brought forward, . . . | $75·55 |
| Add one-half of this expense ($18·20) to the under-ground expenses on one breast, . . . | 9·20 |
| Total expenses for one breast in 24 hours, . . | $84·75 |
| Average number of days worked per month, | 23. |
| 23 days at $84·75, . . = | $1949·25 per month. |

The amount taken out as bottom was 17·5 cubic yards per lineal foot, and the average number of feet worked per month was 27 on one breast, making 472·5 cubic yards per month.

| | |
|---|---|
| 472·5 cubic yards at $4·12½ . . = | $1949·06 |
| Expense per month, as above, . . . = | $1949·25 |
| Cost per cubic yard, . . . . | $4·12½ |

To this cost it would be safe to add 12½ cents per yard, for tools, &c., and for trimming the sides and bottom before laying the permanent tracks.

With regard to the expense of sinking the shafts, I can say nothing further than that from all I can learn, those of the Bergen Tunnel being large (16 × 20) and generally dry, did not differ much per yard from the cost of the heading. They are from 80 to 90 feet deep.

The rock through which the tunnel is bored is basaltic trap, and said by miners to be a good rock to work, blasting well, though hard to drill.

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*Observations on the Niagara Bridge.** By PETER W. BARLOW, Esq., C.E., F.R.S., F.G.S., &c., &c.

(Continued from page 22.)

## *On the Mechanism of Bridge Construction.*

In the following table is given the weight of metal, deflection, and ratio of ultimate strength to strain by weight of bridge, in the Niagara Bridge, and in those of the longest girders:

| Name of Bridge. | Depth. | Span. | Weight. | Deflection. | Ratio of Strength to Strain by Weight of Bridge. |
|---|---|---|---|---|---|
| | ft. | ft. | tons. | tons. | |
| Niagara, . . | 59 | 820 | { cables, 400 / wood, 600 } | 0·82 ft. with 326 | 6·5 to 1 |
| Britannia, . . | 30 | 460 | 1550 tons. | 2 in. with 248 | 3·4 to 1 |
| Conway, . . | 24 | 400 | 1150 " | 0·69 in. with 100 | 3·8 to 1 |
| *Saltash, . . | 54 | 450 | 1100 " | 1·17 in. with 384 | 5·0 to 1 |

* See Report of Col. Yolland, in the Appendix.

My object is now to endeavor to explain why these differences are consistent with understood mechanical laws, and the peculiar properties of the material employed.

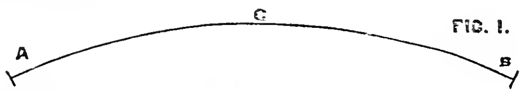


FIG. 1.

Let A B C, Fig. 1, represent an arch supported on abutments, A and

*From the London Engineer, No. 253.

B; and let the deflection produced by a given weight, loaded equally, be represented by unity.

Now, let us consider the effect of making this arch into a self-supporting structure, or bow-string girder, by removing the abutments and substituting a tie, A B, Fig. 2.

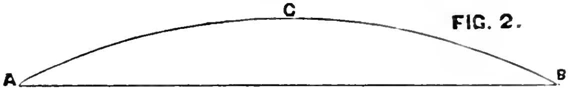



FIG. 2.

Assuming the same weight, W, to be placed equally all over, the deflection will be 2, the points A and B being no longer rigid, because the tie, A B, will extend as much as the arch, A C B, will compress. Therefore, to produce the same rigidity in a bow-string girder, four times the metal is required as compared with an arch.

The same result arises in a cable, A C B, suspended from two fixed points, A and B, Fig. 3.

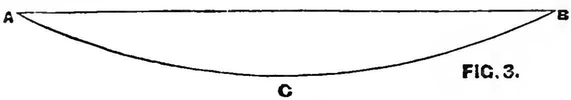
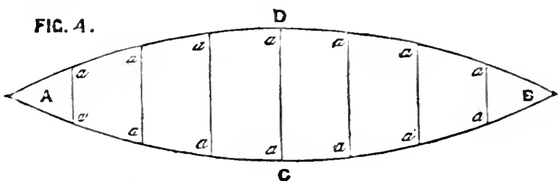



FIG. 3.

If the back chains are removed, and a compression-tube, A B, substituted, the metal is doubled, and you have a structure with only half the rigidity. The Chepstow Bridge, on the South Wales Railway, is an example of this arrangement.

The mechanical combination in the Saltash Bridge is represented by substituting the arch, A D B, for the tie, A B, Fig. 4, forming a combination of a suspension chain and an arch.

FIG. 4.




The arch, A D C, will not perform the duty of compression unless it is connected with the chains by the ties, *a a, a a*. When thus connected, both the cables and the arch assist in supporting the weight of the load.

The points A and B now become fixed points, and, as both the arch and the chains assist in supporting the weight, the deflection will only be half that of the simple suspension-cable, with double the weight of metal.

It therefore appears—1st, To convert an arch, supported on two fixed abutments, into a bow-string girder, four times the metal is required to support the same weight with the same deflection.

2d, To convert a cable, suspended from two fixed points, into a Chep-

stow girder, four times the metal is also required to support the same weight with the same deflection.

3d, To convert the same cable into a Saltash combination, (which consists of a bow-string and Chepstow girder combined, so that their horizontal tie in one case neutralizes the compression-tube in the other, by which they are both avoided,) the deflection is reduced one-half, with double the weight of material, or the same weight of metal will produce the same deflection with the same load, as in the case of the simple arch or cable. But this is obtained at the expense of double the depth; and if the arch or suspension-cable was of the same depth as the Saltash, only one-quarter of the metal would produce the same stiffness.

In the preceding illustration the bow-string and Saltash girders are referred to: parallel girders are more commonly used, but they present no economy over the simple bow-string; and, however perfect their arrangement and proportions, they will still require not less than four times the metal of a simple cable of the same depth and span to produce the same deflection.

Theoretically the same saving will be produced by an arch, but practically it does not hold good in large spans, because of the difficulty previously referred to of dealing with severe compression, and which difficulty applies also to deep girders. You are never certain of the section of metal required on a large scale, as by no calculation can the point be arrived at with certainty when distortion will commence, and thus the section of metal adopted is greater than would be required if the simple compression resistance had alone to be contended with.

The same objection does not apply to the suspension bridge, and as the resistance to tension alone has to be contended with, it may be known precisely what will be the ultimate strength of your structure; and hence arises another source of economy on this principle, in excess of the saving of one-fourth above described.

There is a third source of economy in suspension bridges which has to be noticed, namely, that iron intended for tensile strains admits of a process of manufacture by which a much greater power of resistance per square inch may be given to it than can be accomplished in iron intended for compression, which is proved by all experiments on iron wire, which exhibits a tensile resistance double of any metal used for compression strains.

These practical reasons, in addition to the mechanical laws previously described, when examined in detail, fully demonstrate the reason of the degree of strength obtained in suspension bridges with a weight of metal so small as compared with that of parallel girders of less span; and the only question of doubt, with reference to the advisability of this construction, is the possibility of curing the undulation and vibration which have generally been observed; and it is to this subject that my experiments, laid before the British Association, were directed.

*On the Cure of the Undulation of Suspension Bridges.*

A suspension cable or chain has so evidently no power to resist a

transverse strain, and a large wave or undulation is so readily produced by a vertical force, in bridges of small span and weight, that it is surprising that a suspension bridge was ever designed without giving longitudinal stiffness to the platform of the roadway.

It has been assumed that the degree of longitudinal strength, or girder power, to cure the wave from railway traffic, would require to be so great that the girder would carry the traffic without the cable, and thus the failure of the Niagara Bridge was predicted; but a brief consideration of the subject satisfied me that such an assumption was far from the truth.

The formula $\frac{l^3 w}{bd^3\delta}$ = a constant quantity, $\delta$ denoting the deflection, and $l$, $b$, $d$, the length, breadth, and depth of a beam is fully established; or, in other words, the deflection of a beam with a given weight diminishing as the cube of the length.

Fig. 5.


If the beam, A B, Fig. 5, be divided into two beams by being supported at C, the two half beams, A C and B C, will deflect one-eighth of the amount of the entire beam, A B, with the same weight. Let us assume this to be a girder attached to a chain, and a load placed at D, the effect will be to distort it into the shape shown in Fig. 6.

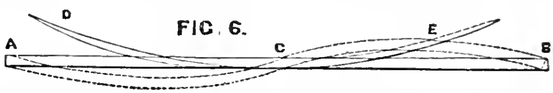


FIG. 6.

The deflection by the weight at D will cause a corresponding elevation at the point E, and the girder will assume the shape represented by dotted lines in the figure, to produce which a force equal to double that for a given deflection on half the beam is required, from which it is evident that the wave produced by a given weight at D, will only amount to one-sixteenth of the deflection the same weight will produce on the entire beam resting on its two ends.

In the above proposition it is assumed that the beam is supported at its centre point only; in practice, when attached to a suspension cable, it is supported at various points of its length; the difference between the wave of a supported girder and the deflection of an unsupported girder, will therefore be greater than one-sixteenth.

In order to arrive at the result by experiment, I had a model of the proposed Londonderry Bridge, on a scale of $\frac{1}{33}$d of the actual span, the length being 13 feet 6 inches between the bearings, a length exceeding that of the average of the models used by the Iron Commissioners in their experiments, and is amply sufficient, due allowance being made for the scale, to determine the accuracy of the deflections on the actual girder.

The principal object of these experiments was to ascertain the de-

flection of the wave of a girder attached to a chain, as compared with the deflection of the same girder detached, which being obtained, it is perfectly easy to arrive at the deflection of the wave of any required suspension girder, because we have sufficient experiments on actual girders of various dimensions, to obtain the deflection from a given load on the same girder not attached to the chain.

These experiments gave a mean result of $\frac{1}{25}$th,* so that, it being first determined what amount of deflection is to be the limit with a given load in a given bridge, you have only to arrive by calculation at the sections of metal of a girder of the same depth which would deflect twenty-five times that amount.

To illustrate the mode of proceeding in the intended Londonderry Bridge. It was decided by Sir W. Cubitt that the depth of girder should be 16 ft. 6 ins., and that no wave or deflection should exceed 1·32 in. with 100 tons. I obtained by deduction from the deflection of the Boyne Viaduct, Newark Dyke Bridge, Britannia Tube, &c., that a girder of 3700 tons, of the depth of 16 ft. 6 ins., would be deflected 1·32 ins. with a weight of 100 tons; one-twenty-fifth, or 150 tons, is therefore the weight of girder required for the Londonderry Bridge.

The reduction of the deflection of a girder when attached to a chain may appear so great as to lead to doubt of the accuracy of the experiments; but it is not more than is fully explained by the law $\frac{l^3 w}{b d^3 \delta}$ and is consistent with such results as have been obtained in actual suspension bridges.

The Inverness Bridge, built by Mr. Rendell, had an iron parapet only 3 ft. 6 ins. deep, and yet the wave is so reduced, as reported by Mr. Rendell, as to be imperceptible to the eye when a locomotive passed over it on a truck. In the Keif Suspension Bridge, in Russia, which has a wooden trussing of about 6 ft. deep, and the Menai† and all other bridges, when any attempt, however small, has been made to give longitudinal strength to the platform, the wave has been so reduced as to be unobjectionable.

In the Niagara Bridge, which is the only bridge used for railway traffic, the longitudinal stiffness is given by timber trussing 18 ft. in depth. According to my rule, a girder of 370 tons would be required, so that no wave shall exceed 2 ins. The actual girder power of this timber trussing I estimate to be no more than could be obtained by 100 tons of good iron well arranged; so that the actual wave observed (about 4 or 5 inches) evidently does not exceed what my calculation would give, and fully bears out the result of my experiments.

* See my Paper on Suspension Bridges, published in the "Report of the British Association," 1857.

† The means used to give longitudinal strength to the Menai Bridge consists only of two beams about 12 inches square under, and 4 over, the platform; the girder power of which is much less than, according to my experiments, should be given; and should this or many other bridges now existing suffer injury in a severe hurricane, it will in no way be inconsistent with the views here expressed.

(To be Continued.)

Translated for the Journal of the Franklin Institute.

## *Co-efficient of Friction on Railroads.*

We extract the following tables of experimental results, from a report made by a Committee of the French Society for the Encouragement of National Industry, upon a kind of shoe-brake, invented by M. Didier.

TABLE I.—*Experiments in which the car, provided with the Didier brake, was left to itself at different velocities.* Grade 0·0015 m. Rails dry. Shoes wooden:

| | Total weight of car. | Weight on the shoes. | Velocity of car at beginning of experiment per hour. | Time before the shoes bore. | Whole space passed over. | Space passed under action of brake. | Calculated co-efficient of friction. |
|---|---|---|---|---|---|---|---|
| | kilometres. | kilometres. | kilometres. | seconds. | metres. | metres. | |
| 1 | 10,000 | 8,500 | 16·55 | 3 | 50 | 36 | 0·035 |
| 2 | " | " | 54· | 3 | 125 | 80 | 0·191 |
| 3 | 11,500 | 10,000 | 82·80 | 6 | 328 | 190 | 0·161 |
| 4 | " | " | 87·80 | 5 | 322 | 200 | 0·173 |
| 5 | 10,000 | 8,500 | 41·70 | 3 | 68 | 57 | 0·235 |
| 6 | " | " | 54·70 | 2·5 | 94 | 37 | 0·241 |
| 7 | " | " | 7·40 | 5 | 154 | 74 | 0·205 |

TABLE II.—*Experiments in which the car, with the Didier brake, was left to itself at various velocities.* Grade of the railroad 0·0015 m. Shoes wooden. Total weight of car 10,000 kilogrammes. Weight borne on shoes 8500 kilogrammes.

| | Velocity at beginning of experiment per hour. | Time before the shoes bore. | Space passed over before stopping. | |
|---|---|---|---|---|
| | kilometres. | seconds. | metres. | |
| 1 | 36 | 2 | 46 | Rails dry. |
| 2 | 41·7 | 3 | 68 | " |
| 3 | 46 | 3 | 61·5 | " |
| 4 | 54·7 | $2\frac{1}{2}$ | 94 | " |
| 5 | 64·4 | $3\frac{1}{2}$ | 117 | " |
| 6 | 63·1 | $3\frac{1}{2}$ | 131 | Rails wet. |

TABLE III.—*Experiments in which a car, furnished with the common brake, was left to itself at different velocities.* Grade 0·0015 m. Weight of car 10,000 kilogrammes.

| | Velocity of car at beginning of experiment per hour. | Space passed over before stopping. | |
|---|---|---|---|
| | kilometres. | metres. | |
| 1 | 20·5 | 30 | Rails dry. |
| 2 | 57·6 | 213 | " |
| 3 | 59 | 170 | Rails dried by wind after rain. |
| 4 | 61·2 | 205 | Rails dry. |
| 5 | 68·4 | 251 | " |

NOTE.—The kilogramme = 2·2 lbs; the kilometre = 0·62 statute mile; the metre = 1·094 yards.

For the Journal of the Franklin Institute.

*Repairs and Renewal of the Roche-Bernard Suspension Bridge.* From a description given by M. NOYON, Engineer. Translated by J. BENNETT.

PART FIRST.

The first part of this notice presents the circumstances and causes of the accident which befell the Roche-Bernard bridge in the hurricane of Oct. 26th, 1852, and an examination of the modes proposed for its consolidation and protection against the action of storms; the second describes the works effected for accomplishing this two-fold result, as well as different processes and details of execution peculiar to the work.

*Fall of the Platform.*—On the 26th Oct., 1852, the platform of this bridge, being violently disturbed by a tempest which raged for two days among the Morbihan hills, was broken into many parts, and almost entirely precipitated into the Vilaine River. After the rupture, which was instantaneous, there remained but three portions; one between the centre of the span and the right bank abutment, the two others near the piers.

Happily, no one was upon the bridge at the time, though, a few minutes before, a stage coach passed over it; the horses swayed by the wind, frightened by the noise and the insecure foothold, reared and baulked; but the driver having mastered them, urged them at a full gallop, and so escaped the danger.

The bridge-keeper was the only one who witnessed the accident, and he could give but vague and contradictory accounts of it; so that all would have been left to mere conjecture, but for the clear indication of the causes of the disaster, derived from an inspection of engineers the day after the event, and from the nature of movements to which suspension bridges of large span are exposed.

*Condition of the Cables.**—From the report of M. Grégoire, the suspension cables suffered no change but that arising from the shocks against the porches at the points where they enter the masonry, and was limited to tearing away the ligatures in these parts; so likewise for the retaining cables, at their entrance into the pedestals which covered the mooring chambers. In the galleries, some five or six wires per cable were cut by the friction against the side masonry. The mooring cables were uninjured. The only trace of vibration naturally sustained by the whole system of suspension was the cracking of the paint and dried oil varnish surrounding the cables throughout their length.

*Condition of Masonry.*—No fissures were discovered in the resisting parts. The cut-stone masonry of the piers which bore the cast iron plates receiving the friction rollers was undisturbed, and the mortar at the joints was intact. In the mooring chambers, where all the points of support are upon the rock itself, there were found slight

* Suspension cables bear the platform; retaining cables, the inclined part between towers and galleries; mooring cables secure the retaining of each bank.

cracks in the cement lining which covered the masonry revetment of the vertical pits, near the cushions, which must have been moved by the sheering and slackening of the suspension cables.

There was a partial destruction of the pedestal cornices and pier crowns, near the entrances of the retaining and suspension cables.

On the down-stream side some stones were raised and moved; on the up-stream some were thrust violently outwards, and fell upon the platform, or upon outside of pier.

*Condition of Platform.*—Three portions of the platform were left suspended to the cables; the first, on the opposite side of Roche-Bernard, had 19 suspension beams, 17 of which were fast in the stirrups at both ends, while the two others were, the one nearly and the other wholly, freed from them on the down-stream side.

A second portion, composed of 22 suspension beams and covered with the flooring, was separated from the first by a space of 21 intermediate rods; on the up-stream side, 19 of the beams were in their stirrups, while on the down-stream, 10 only, in the middle part, were partially or wholly fast to them. The connexion of the carpentry was all that prevented the fall of the extreme portions.

A third portion, on the Roche-Bernard side, was composed of 20 beams, completely fast in the stirrups on the up-stream side, and free from them on the down-stream side.

*Rods, Stirrups, and Yokes or Supports.*—The suspension rods answering to the broken portions of the platform, were for the most part intact on down-stream side; ten only were broken or bent, the others having preserved their forms. The stirrups were in their place, two only being ruptured from defective iron. But on the upper side, the rods bear marks of violent commotions, being all more or less damaged, while some were bent double, and one turned completely over the cable. Some of the yokes were broken.

*Ruins of the Platform.*—The platform from its fall was naturally broken in all directions; the railing which had been bolted to the suspension beams was detached. The five fallen portions may be considered as of equal lengths with the suspended, and it may be admitted, that at the moment of rupture, the platform was divided into eight parts, containing each 22 or 23 beams.

*Different Observations.*—1st. The friction rollers upon which rest the suspension cables, at the origin of the parabolic curve, had all slid upon their plates towards the river, and were displaced from two to five inches.

2d. The joists of the flooring, the stringers of the side walks, the only pieces connected with the suspension beams, were mostly rotten at the core. The side railing, as well as other parts of the carpentry, with fourteen years use, were no better, and were completely smashed in the fall of the platform.

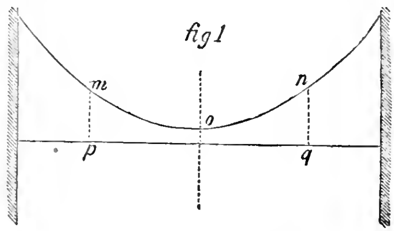
3d. The distance between the suspension cables of the two sides, being greater than the length of the beams, the latter naturally tended to escape from their stirrups, especially in the central part. Great pins had been placed back of the stirrups to prevent the sliding; they

were wholly detached from the beams that had fallen, and on the down-stream side of those in suspension were all more or less bent.

Before drawing conclusions, it may be well to examine the different movements most frequently produced by suspension bridges of large span, under the action of wind.

*Vertical Oscillations.*—In all bridges the curves of the chains or cables are easily deranged, and the changes produced by an increased or diminished tension at any point, occasion marked perturbations in the conditions of equilibrium.

Thus, when a transient load presses a portion, *p*, of the platform (Fig. 1), this portion and the corresponding element, *m*, of the cable falls, and on rising to resume its normal position it passes by it, and oscillates until the quantity of motion imparted is consumed by the resistances of the displaced mass. While the points *m* and *p* thus vibrate, other points, *n* and *q*, on the other side of the summit, *o*, of the curve oscillate in an opposite direction. In virtue of the flexibility of the system, they fall when the first rise, and *vice versa*. The summit of the cables is also displaced, passing right and left, above and below its normal position.



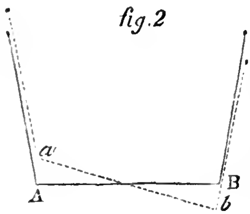

The effect in this case is more apparent as the disturbing force is in greater ratio to the mass of the bridge; if this force is renewed at short intervals, the agitation increases rapidly, and may acquire sufficient intensity to produce a rupture of the cables.

The wind exerts an action similar to that of the transient load. Pressing against the under surface of the platform, it diminishes the weight borne by the cables, which from their tension are raised, and fall when the disturbing force is diminished or ceases to act. Hence arise vertical oscillations, whose amplitude varies with the violence or duration of the wind. In a storm, when squalls succeed at short intervals, such oscillations are produced at different points, and may have a development capable of deranging or utterly destroying the most solid platforms.

The vertical oscillation, being an immediate and natural consequence of the flexibility of the cables, of the facility with which they are disturbed, and of the little rigidity of the whole system, all else being equal, it should be less marked, as the mass is more considerable, and as the ratio of the rise to the chord of the cables is smaller; especially in the middle and extremities, because these parts for a considerable distance differ but little from a straight line, and because the platform is nearly directly attached to the cables, or made fast with the piers; on the other hand, it should be very marked at $\frac{1}{6}$th of the span from the origin, where the rods are all long, and where the cables, for the same horizontal projection, have a greater development, and accordingly more flexibility.

Vertical vibrations being necessarily frequent, wear upon the bonds of carpentry in platforms, and at length injure and displace them, and by reason of the great amplitude which they attain, occasion some inconvenience to the travel, for the movements impressed are in some cases similar to the pitching of ships.

*Transverse Oscillations.*—When two corresponding elements of the up-stream and down-stream cables oscillate in opposite directions, either from direct actions or reactions, one side of the platform is raised above its normal position, while the other falls below it, with an effect similar to the rolling of ships. This movement, always manifest in high winds, is very prejudicial to the platform, causing the travel to be laborious, if not impossible, while an absolute displacement of 8 inches of the points A and B causes a difference of 16 inches in level between the heads of the bridge.




*Undulations.*—If the vertical oscillations effected at the same time in different parts of the cable are continuous and concurring, they are spread in succession, and unite, so that the platform undulates like the sea agitated by the wind. Though generally small in amplitude, they disturb the carpentry work, and by reason of the alternate flexures in opposite directions finally injure the elasticity of the wood.

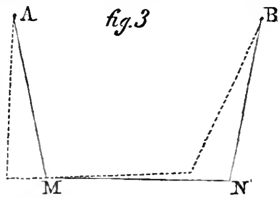
*Raising of the Platform.*—The wind frequently acts simultaneously upon many points of the under surface of the platform. The cables being thus relieved of a portion of the weight usually borne by them, rise and draw up with them the platform; when the disturbing cause ceases, they fall, and oscillate about their initial position before definitely resuming it.

This effect does not occur, at least to any great extent, except in high winds or great squalls, and at quite distant intervals. Should they become continuous, the whole bridge would oscillate without interruption, and would impart a *vis viva* sufficient to break the platform and the cables.

When movements of this kind occur, the platform is not, properly speaking, raised by the wind; it is simply drawn by the tendency of the cables to assume a curvature corresponding with the new conditions of equilibrium, determined by the disturbing force, and the suspension beams do not cease to rest upon their stirrups.

*Horizontal flexure and translation of the Platform.*—It is quite natural to suppose that the platform of a suspension bridge, under the action of wind, would be deflected in the middle (the same as a stick of timber secured at the ends and uniformly loaded), and even be displaced in mass, when not solidly fastened to the abutments; but such is not the case; the horizontal flexure of the platform of the Roche-Bernard bridge during the greatest storms did not exceed from 8 to 10 inches.

As to the motion of translation in mass, various observations have shown that it was almost inappreciable; with so great resistances opposed to the action of the wind, it could not reach an appreciable extent. Thus any portion, M N, of the platform could not be horizontally displaced without rising a little, since the points A and B are fixed, and the rods are rigid. Now the rising must consume a large part of the acting force; and as in great storms there are short intervals of lulls, the platform is brought back quickly by its own weight to its normal position; so that the effects of the wind disappear nearly as soon as they are produced.




On the other hand, the friction of the rods upon their yokes, the form of the suspension cables, the small space generally existing between them and the platform in the middle of the span, and finally, the more or less perfect solidity of the different parts, all combine to prevent oscillations and displacements in a horizontal direction.

*Causes of the Fall of the Platform.*—The simultaneous existence of the above described movements, and their intensity during the tempest of October 26th, explain the fall of the platform of the bridge. Probably, after having been strained for a long time in all directions, it oscillated *en masse* many times in succession, and its rupture in eight parts was effected instantly, during a squall, by an oscillation of this kind.

The movement impressed upon the whole system by the first circumstance, the disorder occasioned by it, and the developed *vis viva* imparted to the different parts of the platform after their separation, impulses which drove them far from their normal positions. Then each of them swung separately around their points of attachment, without a cessation of their oscillations, and these two movements, aided by the permanence of the wind and the discordant oscillations, produced wrenches, shocks, and successive displacements, which ended in causing upon the down-stream side the escape from the stirrups, upon which the beams simply rested, and which was inevitable by reason of the obliquity of the rods to the platform, and their tendency to depart from the axis of the bridge, and especially from the inclination A B (Fig. 2), which the direction of the wind, blowing from down-stream up, caused the beams to take.

The up-stream cables then supported alone, though but for a short time, all the weight of the detached platform, and this enormous surcharge so shortened the length and sagitta of the corresponding retaining cables, that they beat against the mooring pedestals so severely as to overthrow four courses of strong cut stone masonry.

The demolishing of the upper part of the sides of the porch facing the river is attributed to the shock of the down and up-stream suspension cables, which, suddenly freed from a considerable load, the first after the escape of portions of the platform, the second after their fall, must have vibrated violently around their final position.

The up-stream cables, on account of their accidental surcharge, oscillated more violently than the others, and so caused more damage to the masonry of the up-stream than the down; the same was the case with the slipping of the friction rollers, which differed from 1 to 1½ ins. between the two heads of the bridge.

As to the displacement of the two fragments of platform, which remained near the towers, and the rupture of their connexions with the wall beams and porches, they were due to the whole system of suspension having been suddenly drawn to the up-stream side, when the cables of this side alone supported the five portions of platform which had escaped from their down-stream stirrups, and to the disorderly oscillations of these parts around their points of fixture.

From the above developments, the fall of the platform is attributed, 1st, to the great mobility of the suspension system; 2d, to the decayed condition of the carpentry connecting the platform beams; 3d, to the absence of all proper means of securing the beams to their stirrups, and to the fact that the vertical oscillations of suspension bridges constitute the most dangerous movements to which they are generally exposed, since, being caused by small surcharges and light winds, they are nearly continuous, and may attain in some cases an amplitude to break the most solid structures.

The Council General of the "Ponts et Chaussées," in approving the project of rebuilding the platform, prescribed a complete fixture of the ends of the beams in their stirrups, and a study of the dispositions required for a more rigid suspension, and for the prevention of oscillations, swingings, and lifts, during tempests.

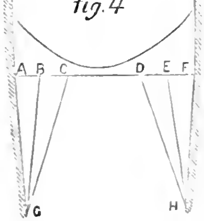
It may be well to examine among the proposed projects those which with a satisfactory solution best reconcile the dispositions of the bridge with the exigencies of the navigation of the Vilaine.

*Means proposed and adopted for consolidating the system of suspension.*

*Guys.*—The most simple and natural method first proposed was a system of guys.

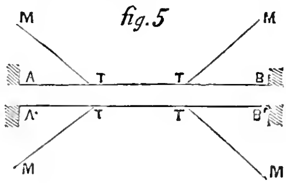
If all the platform beams were solidly connected together on each side of the axis of the bridge by a wire cable fastened to the towers, and if to the cable were attached inclined guys, such as G B, G C, H D, H E, with their ends firmly anchored in the ground or bottom of the river (Fig. 4), it could not experience vertical oscillations of a great amplitude; but it would be exposed to movements resulting from partial changes produced by the wind, or the passage of heavy loads in the intervals A B, B C, C D, &c. But it could not be put in practice upon the Roche-Bernard bridge, on account of interrupting the navigation.

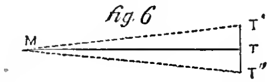
fig. 4




It is true this inconvenience might be avoided by substituting hori-

zontal guys, placed nearly at the height of the roadway. These guys, two on each side, might be secured at their ends, T, to the cables A B, A′ B′ (Fig. 5), connecting the beams together, and at their other ends, in masses of masonry, M, disposed for this purpose upon the hills bordering the Vilaine. Unfortunately, the points, M, could not be had at a less distance than 218 yards from the points, T, and so it would be impossible to give them sufficient rigidity to answer a good purpose; and even admitting that they might have been stretched in nearly a right line, they would by no means be opposed to the vertical oscillations of the platform around their points of attachment, M (Fig. 6), and their extremities, T, could be easily displaced upon the vertical T T′; for an elongation of ·04 of an inch would suffice to lower the point, T, over a yard.

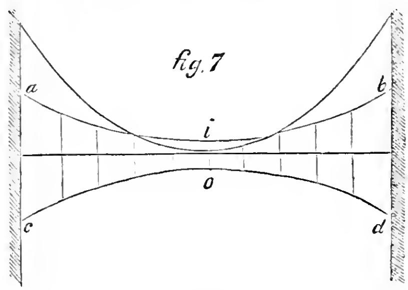



*M. Leblanc's System.*—In a letter addressed to the Minister of Public Works shortly after the fall of the bridge, M. Leblanc, the Chief Engineer, suggested a plan which, in his judgment, would prevent the rising, and so the removal of the platform.

Thus he describes it:

"If it were possible to establish between the towers of suspension bridges a rigid and unyielding bar of iron, to which the platforms might be fastened, they could not be raised; but though it may not be possible to establish such a bar, it is easy by means of two cables, *a i b*, *c o d* (Fig. 7), with their convexities turned towards each other, and connected by vertical ties, to form a rigid system, equal to that of the iron bar. I have proved it with ropes upon a great length.



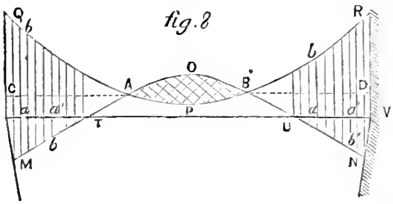

"By applying such a system of rigid axes, either above, below, or at the sides of, the platforms, so as to receive no part of the weight of the bridge, and arranged so as to oppose oscillations exceeding 4 inches, the accidents which have befallen the Beaucaire and the Roche-Bernard bridges might have been prevented."

Though it might be difficult upon this simple statement to account for the efficiency of this method, and to appreciate, *à priori*, the merit of an untried arrangement, it would seem to present much rigidity, and by reason of the numerous connexions between the auxiliary cables, and between the platform and the cables, it would be impossible for any point of the platform to rise or fall without creating in other parts resistances which should oppose its movement and arrest it at once.

Unfortunately, to apply this system without obstructing the navigation, it would be necessary to place one of the cables below the platform and the other above, and consequently to make the points of fastening quite high in the porches, and to pierce the masonry through and through, and so mutilate and disfigure the edifice. On the other hand, the upper cable would have been wholly visible, and would have an unsightly appearance.

Finally, the difficulty of making eight holes, from 16 to 23 ft. deep, through very hard granite masonry, traversed in all directions with iron bars and cramps, besides other reasons which might be enumerated, forbade the adoption of this system.

*Oudry's System.*—Another more complicated mode of consolidation somewhat similar to the above, was proposed by M. Oudry, engineer:




Let Q A P B R (Fig. 8), be a suspension cable, and M T A O B U N, a counter cable, with the portion A O B, parabolic, and straight in the parts, M A, and B N.

If the two cables are firmly united at A and B, their intersection, and if the space comprised between the parabolas, A O B and A P B, is exactly filled by a rigid spandril, such as A O B P, and the points A and B are secured to the towers by horizontal guys, A C and B D, the points, A, B, are in an invariable position; for when the first tends to approach or recede from the adjoining abutment, S, the invariable form of the fish-bellied spandril, A O B P, determines a second inverse motion in respect to the opposite abutment V; every displacement of the points A, B, exacts the receding of one of them from its adjoining abutment, an impossibility, since the first of these points is retained by the two inextensible rods, C A, and M A, and the other by the two rods, B D, and B N.

The fish-belly being invariable in form and position, the portion of the platform directly attached to the arc, A P B, is in a similar condition, however little the counter cable may be secured to the platform at the points, T and U.

As to the invariable form of the platform in the parts, S T and U V, it may be attained by connecting the ends of the beam with the cables, Q A and B R, by vertical wrought iron rods, *a b*, of a certain rigidity, with symmetrical oblique wire rods each side of the vertical, bound together with straight rods at their points of crossing. The invariability is also greatly increased by connecting with the platform the pendent rods, *a' b'*, required for supporting the counter cable, and for holding straight the portions M A and B N.

Thus the efficiency of this system rests solely upon the unchangeable form and position of the fish-belly, and of the portions of the platform not directly secured to it; it exacts, 1st, the crossing and connexion of the suspension cables with the counter cables; 2d, the use of horizontal guys fastened in the abutments; 3d, the establish-

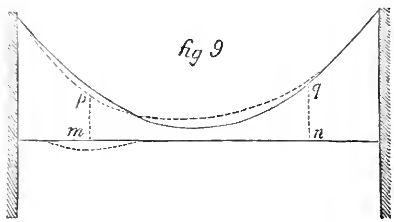
ment of oblique rods, constituting with the bridge rods an unchangeable trellis work.

The most of these conditions cannot be realized for the Roche-Bernard bridge without difficulties and injury to the appearance of this beautiful monument, and a trial of this system was never entertained a single instant.

*Counter Cable resting upon the Ends of the Beams.*—Another method, which has already been applied to several suspension bridges in France and England, consists of a safety cable, a kind of counter cable, solidly secured to the abutments at the level of the platform, and resting upon the ends of the beams.

Such a cable increases the rigidity, but does not completely prevent the oscillations of the platform, though it may diminish their amplitude, especially if there is a certain length given to the sagitta of curve.

If a point, *m*, of the platform lowers by the effect of a surcharge, the element of suspension, *p*, also descends; consequently, the cable changes its form, and the point *q*, corresponding with the point *p* (Fig. 9), tends to rise; but as the counter cable remains stiff at *n*, and presses strongly upon the platform, it is opposed to the motion of the point, *q*. On the other hand, when the surcharge ceases to act, the point, *m*, returns to its initial position, and can only surpass it a small quantity, since the counter cable on returning to its first position acts so much the more energetically upon the platform at the point, *m*, as it has experienced a greater than the normal tension, by reason of the reaction, which determines the tendency of the point, *n*, to rise at the same time with the point, *q*.




Thus, the acquired velocity of the point, *m*, if not destroyed, is at least diminished by the resistance of the counter cable; consequently, the amplitude and duration of the oscillations become much less, and as the *vis viva* developed in the suspended mass is neutralized almost immediately, the disturbing cause may be renewed, even at short intervals, without causing a serious displacement of the platform.

This method is especially effective against the action of the wind; it evidently prevents the lifting *en masse;* it opposes and so arrests promptly the partial oscillations, and wholly prevents tumultuous movements and the disorder natural to a system which offers no opposition to an accumulation of *vis viva* imparted by an incessant cause, and producing by a series of uninterrupted oscillations, terrible shocks which cannot be resisted.

That this method may produce satisfactory results, it is important that it should have strength enough to contend against the most violent winds; the counter cable must therefore be made of a great many

wires, as the sagitta of the curve equal to the convexity of the platform, is very small compared with the span, and as their tensions on the rising of the platform are inversely proportional to this rise.

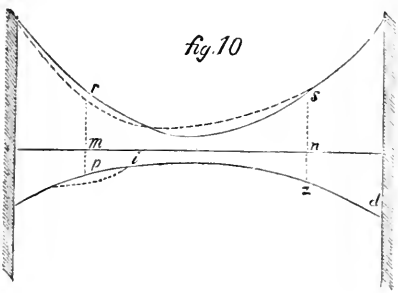
Various reasons forbid the application of this system to the bridge. It would have been necessary to establish the mooring points in the piers of the porches, which would be attended with the inconvenience already indicated in the method of M. Leblanc.

On the other hand, these points would have to be at least 2 ft. above the platform at its origin, and thus the rise of the curve of these cables would only be 4·26 ft. — 1·96 ft. = 2·3 ft.; so that very small variations of temperature would produce a marked increase in length of sagitta, by which the efficiency of the method would be much diminished.

Finally, on account of the position of the mooring points, the safety cables could not rest upon the first twenty beams, and so the results would be incomplete.

*Counter Cable below the Platform.*—The combination finally adopted differed but little from the preceding, but is much more satisfactory; it consists in placing the safety or counter cable below the platform, and securing it to the ends of the beams by rigid rods. In this position it would produce an effect similar to that of a cable resting upon the ends of the beams.

Thus, when the point, $m$, of the platform (Fig. 10) is lowered, the point, $p$, of the counter cable will fall, being deprived of its support; but the portion, $izd$, of the curve will not change its form. Therefore, when the point, $s$, of the suspension cable, corresponding to the point $r$, tends to rise, it will be opposed by the resistance of the element, $z$, which cannot rise, but by a total change of the counter cable, a difficult matter on account of its length and its weight.*




When, by any cause, oscillations occur in the platform, the resistance of the counter cable will arrest their development, and prevent an amplitude sufficient to impair the framings of carpentry.

The movements of suspension being thus thwarted at each instant, the centre of gravity of the mass can never acquire a great velocity nor be much displaced; consequently, there is no fear of shocks arising from the accumulation of *vis viva*, or of a repetition of the accident which befell the Roche-Bernard bridge.

The efficiency of the system in question being so much the greater as the changes in the counter cable, from dilation or extension of the

* There is a difference in the reactions of the counter and suspension cables, the latter bearing a permanent load, while the others are simply supported, and the equilibrium of the latter depends upon the tensions to which they are subjected, and that of the former only upon the immobility of the platform.

wires, are less prominent, it is essential to give a good length to the sagitta.

Without prejudice to the navigation of the Vilaine, it could be set at 25 ft. Moreover, to increase the rigidity of the system, the mooring points of the counter cables are set outside of the vertical planes passing through the ends of the beams; so that the curve described by each of them is projected horizontally in a curve line, with a sagitta of 6·5 ft.

This secures against horizontal movements which the wind tends to impart to the platform.

*Various provisions.*—The administration prescribed placing under the platform a course of substringers, 7·8 ins. by 8·6 ins. square, corresponding with the interior stringers of the side walks, firmly connected with the latter and the suspension beams, either by bolts or loops.

It further decided to have the ends of the platform invariably fixed to the towers. This was done by bolting the four first beams of each side, as well as their corresponding stringers, upon two strong pieces of oak, made fast to the masonry at the level of the torus of the base of the towers.

To prevent the beams from slipping out of their stirrups, there was placed at each end, in the rear of the latter, a horizontal pin, passing through and projecting 2 inches upon their side faces.

*Change in System of Mooring Cables.*—The dispositions adopted by the Chief Engineer, Leblanc, for mooring the cables, were so defective that he was the first to point out their principal unfitness.

Without following the details, suffice it to say, that though in point of solidity M. Leblanc had left nothing to be desired, yet the advantages in this respect were completely annulled by the conditions of its application, and beside the radical faults pointed out by this engineer, it was attended with other serious inconveniences. Thus, in the part where the mooring cables are inflected to penetrate the vertical pits, they spread out in sheets $4\frac{1}{4}$ feet wide, so near the bottom and sides of the tunnels as to leave no room for introducing the arm. Between this point and that of the union of the retaining with the mooring bundles, forming two layers, one above the other, they were close to the ground, and so the entrance to the covering pedestals, as well as to the vertical wells, was inaccessible, for the wide sheets occupied the whole width of the gallery, so much so that it became necessary, for preventing friction, to separate them from the masonry by wooden wedges. To this we must add the constant strife against the filtering water of the rock cliffs, where recourse was had to various expedients, such as cement packing, side draining, and plank roofing.

These means, devised mostly by the keeper of the bridge, were not sufficient to protect the wires from the effects of moisture, and for a long time all the accessible parts were covered with putty and greasy substances, which, annually renewed, ended by forming a thick and nearly impermeable layer. Unfortunately, this coating could not be applied to the under side of the sheetings, nor upon the portions

buried in the mooring wells, precisely where it was most needed, and where the wires were directly exposed to the oozing of water, or moisture of the ground.

Such a state of things caused much uneasiness, and the upper administration were urgently solicited to provide a prompt and energetic remedy against an evil which time would aggravate; and for this purpose proposals were made for the construction of new galleries, and for the repairs and removal of the mooring cables on each bank. In furtherance of these proposals it was stated, that there was an utter ignorance of the state of the wires in the mooring bundles, as certain parts had never been visited since they were put in place, while there was every reason to suppose that a great number had been attacked by rust.

Before acting upon these proposals, the Council recommended an inspection of the cables, to be well assured of the degree of solidity of their various parts. As the suspension and retaining cables as far as the entrance to the pedestals had been carefully examined after the fall of the bridge, when free from all load, they could be unligatured, opened, and separated, and as it had been proved that all the strands were in a good state of preservation, the inspection was limited to the mooring cables proper.

After taking off completely the continuous ligature enveloping the horizontal part in the cross gallery connecting the two vertical wells, hard wood wedges were driven in at different points, and the wires were held apart, so as to see to the centre of the cables. Marked traces of rust were found throughout. Especially near the pillow blocks, at the rounding of the corners, the wires were much altered, and there were found small reservoirs of water discolored with oxide of iron. This water, which was probably introduced in a state of vapor through the voids of the strands, could not have accumulated at these points without having traversed the vertical parts. It was natural, therefore, to suppose that the latter, which were directly exposed to the oozings and drops from the galleries, were also injured.

In the wide sheets which formed the cables on their entrance to the mooring wells, the wires, though marked with rust at many points, were in general much better preserved, much drier, from being better ventilated, and from being without ligatures and a greasy envelope, and so allowing the water which reached them to pass off along them.

To satisfy the prescriptions of the administration, it remained to ascertain whether the suspension and mooring wires had lost any part of their relative or absolute strength.

This question was settled by many trials of their resistance, and by a comparison made with that assigned by the Chief Engineer upon the construction of the bridge.

As for the suspension cables, experiments were made upon wires of strands broken by extreme tension, or worn by the friction of the supporting yokes. These strands, with the exception of those which had shrunk, having been changed, either by a loss of fibrous texture or from the exterior fibres being bruised or cut, the measure of their strength may be regarded as the inferior limit of the intact wires.

Some trials were made upon strands of suspension cables, near the supporting rollers, where the permanent tension is the greatest; thus all the experiments being made upon wires in the most unfavorable condition, their resisting tension may be considered as a minimum of the mean strength of all the strands of the suspension cables.

The results of these trials show:

1st. That the resistance per ·00155 square inches of section was 172·62 lbs. for 34 strands of broken wires, stretched or worn by the rod yokes; 155·95 lbs. for 8 strands near supporting rollers.

2d. That the mean resistance for the 42 trials was 155·15 lbs.

3d. That the mean section of the wires experimented upon was ·014 square inches.

In the description of the Roche-Bernard bridge, M. Leblanc attributing to the wires a mean resistance of 167·62 lbs., the loss of strength would seem to be 12·47 lbs. This result would appear to be too great, and could not be accepted without verification; and on an examination it was found that M. Leblanc had committed an error, and that the primitive force was below 167 lbs.

Without enumerating the calculations, it would seem that the primitive resistance should be set at 158·79 lbs., and that the loss of force since the construction of the bridge did not exceed (2 kil. per mille. square or) 2846 lbs. per square inch.

It was thought that these changes were due to the molecular condition of the wires, arising on the one hand from the influence of the atmosphere, and on the other to the permanent work, and continual vibrations of the cables.

*Loss of Force in Mooring Cables.*—To arrive at the degree of change in these parts, trials were made upon 16 strands much injured by rust, and upon 12 strands in good order taken from the sheets near the entrance of the pits. The latter at the moment of rupture supported a tension of 154·38 lbs. per ·00155 square inch, while the other broke under a tension of 148·51 lbs., a loss of 10·28 lbs. per section of ·00155 square inches.

This notable diminution of relative force arises solely from the change of primitive tenacity by the rust. As for the absolute loss of force, resulting from the disappearance of material consumed by rust, it was scarcely appreciable, for the mean section in good order was ·013779 square inches, and that of the rusted was ·013733 sq. inches, or 4·76 lbs. per strand.

Consequently the presence of moisture had changed the molecular condition of the wires so much, that the absolute force of some was reduced 91·37 lbs.

These results could not fail to be alarming. It was fair to suppose that a third of the wires of the mooring cables, were in a similar condition, and so it was feared that the resistance of the cables might be diminished $\frac{5600}{3} \times 91{\cdot}37 = 170{,}557$ pounds.

This figure was a potent argument in favor of the project, and would

alone have sufficed for its adoption, even if another circumstance had not called for the enlargement of the galleries and the moving of the mooring cables.

The establishment, first ordered, of a counter cable, and a course of stringers under each side of the platform, would increase the weight of the suspension by 72,600 pounds, and the wires, even in the parts which were not to be repaired, having lost a portion of their primitive force, the permanent work to which they would be subject in these new conditions, would have exceeded the limit of 12 kil. per mille. square of section (17,075 lbs. per square inch), first assigned them. The administration, therefore, decided that there should be a third cable upon each head of the bridge, which should bear one-third of the suspension rods. Now the old galleries being completely occupied by the spreadings of the primitive cables, where the retaining bundles are joined with the mooring, it was of course impossible to introduce the new cables; it was therefore necessary to radically change the dispositions and dimensions of these galleries, and to give another form and direction to the mooring bundles, that is to say, to execute the different works proposed, but founded upon wholly different considerations. So that, to resume, independently of the reconstruction of the platform, there were three operations, to wit:

1st. The enlargement of the galleries, and change in the system of mooring cables.

2d. The establishment upon each head of the bridge of a third suspension cable.

3d. The instalment of two safety cables, bound to the ends of the beams by rigid rods.

These operations will be described in Part II.

(To be Continued.)

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## MECHANICS, PHYSICS, AND CHEMISTRY.

For the Journal of the Franklin Institute.

*Strength of Materials:* Deduced from the latest experiments of Barlow, Buchanan, Fairbairn, Hodgkinson, Stephenson, Major Wade, U. S. Ordnance Corps, and others. By CHAS. H. HASWELL, Civil and Marine Engineer.

No. 4.

(Continued from page 43.)

### GIRDERS, BEAMS, LINTELS, &c.

*The Transverse or Lateral Strength of any Girder, Beam, Bressummer, Lintel, &c., &c.*, is in proportion to the product, of its breadth and the square of its depth, and also to the area of its cross section.

The best form of section for Cast Iron girders or beams, &c., is deduced from the experiments of Mr. E. Hodgkinson, and such as have this form of section (⊥) are known as Hodgkinson's.

The rule deduced from his experiments, directs as follows:—Area of bottom flanch, six times that of the top flanch. Flanches connected

by a thin vertical web, only sufficiently thick to have the requisite lateral stiffness, and tapering both upwards and downwards from the neutral axis, and in order to set aside the risk of an imperfect casting, by any great disproportion between the web and the flanches, it should be tapered so as to connect with them with a thickness corresponding to that of the flanch.

When Girders are subjected to impulses, and are used to sustain Vibrating loads, as in bridges, &c., the best proportion between the top and bottom flanch, is as one to four, as a general rule, they should be as narrow and deep as practicable, and should never be deflected to more than one five-hundredth of their length.

In Public Halls, Churches, and Buildings where the weight of people alone are to be provided for, an estimate of 175 pounds per square foot of floor surface is sufficient to provide for the weight of flooring and the load upon it.

In Store Houses and Factories, the weight to be provided for, should be estimated at that, which may at any time be placed thereon, or which at any time may bear upon any portion of their floors: the usual allowance, however, is for a weight of 280 pounds per square foot of floor surface.

In all uses, such as in buildings and bridges, where the structure is exposed to sudden impulses, the load or stress to be sustained, should not exceed from one-fifth to one-sixth of the breaking weight of the material employed, but when the load is uniform or quiescent, it may be increased to one-third and one-fourth of the breaking weight.

An open web girder or beam, &c., is to be estimated in its resistance, on the same principle as if it had a solid web. In cast metals, allowance is to be made for the loss of strength due to the unequal contraction in cooling of the web and flanches.

In cast iron, the mean resistance to crushing or compression and extension, are as 5·5 to 1, and in wrought iron, as 12 to 23; hence the mass of metal below the neutral axis, will be greatest in these proportions, when the stress is intermediate between the ends or supports of the guides, &c.

*Wooden Girders or Beams*, when sawed in two or more pieces, and slips are set between them, and the whole bolted together, are made stiffer by the operation and are rendered less liable to decay.

Girders cast with a face up are stronger than when cast on a side, in the proportion of 1 to ·959, and they are strongest also, when cast with the broadest flanch up.

The following results of the resistances of metals will show how the material should be distributed, in order to obtain the *maximum* of strength with the *minimum* of material:

| | To Tension. | To Crushing. |
|---|---|---|
| Wrought Iron, . . | 23 tons. | 12 tons. |
| Copper, . . . | 16 " | 3 " |
| Cast Iron, . . . | 8 " | 51 " |
| | 8 " | 37 " |

*Hence*, In a wrought iron beam, the upper flanch should be as 23 to 12, or 2 to 1.

The best iron has the greatest tensile strength, and the least compressive or crushing.

The relative strength of girders or beams, cast vertical or horizontal, is as 536 to 514, or as 1 to ·96.

The outline of a girder or beam, both in depth and width of bottom flanch, may be reduced from the required dimensions in the middle, or at the end, as the case may be, at points intermediate between the centre and supports, or end and fulcrum, to correspond to the weight or stress to be borne.

When the Top flanch, the thickness of the web, the length and the depth are unaltered, the web being thin, the strength of the girder or beam, is nearly in proportion to the area of the bottom flanch. (See Enquiry of Samuel Hughes, C. E., &c., Artizan, pp. 148-9.)

The most economical constructions of Girders or Beams, with reference to attaining the greatest strength, with the least material, are as follows:—The outline of their top, bottom, and sides, should be a curve of various forms, according as the breadth throughout is equal, or the depth throughout is equal, and as the girder or beam is loaded only at one end, or in the middle, or uniformly throughout.

*When the Girder or Beam is Fixed at one End, and Loaded at the other.*

1. *When the Depth is uniform throughout the entire length.*

The depth being uniform: The section at every point must be in proportion to the product of the *length*, *breadth*, and *square of the depth*, and as the square of the depth is in every point the same, the *breadth* must vary directly as the length, consequently, each side of the beam must be a vertical plane, tapering gradually to the end.

2. *When the Breadth is uniform throughout the entire length.*

The breadth being uniform: The *depth* must vary as the *square root of the length:* hence the upper or lower sides, or both, must be determined by a parabolic curve.

3. *When the section at every point is similar, that is, a Circle, an Ellipse, a Square, or a Rectangle, the sides of which bear a fixed proportion to each other.*

The section at every point, being a regular figure: For a circle, the diameter at every point must be as the *cube root of the length*, and for an ellipse, or a rectangle, the *breadth* and *depth* must vary as the *cube root of the length.*

*When the Girder or Beam is Fixed at one End, and Loaded uniformly throughout its Length.*

1. *When the Depth is uniform throughout its entire length.*

The depth being uniform: The *breadth* must increase as the *square of the length.*

2. *When the Breadth is uniform throughout its entire length.*

The breadth being uniform: The *depth* will vary directly as the length.

3. *When the Section at every point is similar, as a Circle, Ellipse, Square, and Rectangle.*

The Section at every point being a regular figure: The *cube of the depth* must be in the ratio of the *square of the length.*

*When the Girder or Beam is Supported at Both Ends.*

1. *When Loaded in the middle.*

The *constant* of the beam, or the product of the breadth and the square of the depth, must be in proportion to the distance from the nearest support; consequently, whether the lines forming the beam are straight or curved, they meet in the centre, and of course the two halves are alike.

The beam, therefore, may be considered as one of half the length, the supported end corresponding with the free end in the case of beams one end being fixed and the middle of the beams similarly correspond with the fixed end.

1. *When the Depth is uniform throughout.*

The depth being equal: The *Breadth* must be in the *ratio of the length.*

2. *When the Breadth is uniform throughout.*

The breadth being uniform: The *Depth* will vary as the *square root of the length.*

3. *When the Section at every point is Similar, as a Circle, Ellipse, Square, and Rectangle.*

The section at every point being a regular figure: The *cube of the depth* will be, as the square of the *distance* from the supported end.

*When the Girder or Beam is Supported at Both Ends and Loaded uniformly throughout its length.*

1. *When the Depth is uniform.*

The depth being uniform: The *breadth* will be as *the product of the length of the beam, and the length of it on one side of the given point,* less the square of the *length on one side of the given point.*

2. *When the Breadth is uniform.*

The breadth being uniform: The depth will be as *the square root of the product of the length of the beam, and the length of it on one side of the given point, less the square of the length on one side of the given point.*

3. *When the Section at every point is similar, as a Circle, Ellipse, Square, and Rectangle.*

The section at every point being a regular figure: The *cube of the depth,* will be as the *product of the length of the beam, and the length*

*of it on one side of the given point, less the square of the length on one side of the given point.*

*General Deductions from the Experiments of Stephenson, Fairbairn, Cubitt, Hughes, &c.*

Fairbairn shows in his experiments that with a stress of about 12.320 lbs. per square inch on cast iron, and 28,000 lbs. on wrought iron, the sets and elongations are nearly equal to each other.

A Cast Iron beam will be bent to one-third of its breaking weight, if the load is laid on gradually, and one-sixth of it, if laid on at once, will produce the same effect, if the weight of the beam is small compared with the weight laid on.

*Hence*, Beams of cast iron should be made capable of bearing more than six times the greatest weight which will be laid upon them.

In Wrought Iron beams, the upper flanch should be larger than the lower, in the ratio of 2 to 1. The breaking weights in similar beams are to each other as the squares of their like linear dimensions. That is, the breaking weights of beams are found by multiplying together the area of their section, their depth, and a *constant*, determined from experiment on beams of the particular form under investigation, and dividing the product by the distance between the supports.

Cast and wrought iron beams, having similar resistances, have weights nearly as 2·44 to 1.

The range of the comparative strength of girders, of the same depth, having a top and bottom flanch, and those having bottom flanch alone, is from having but a little area of bottom flanch to a large proportion of it, from less than one-half to one-quarter greater strength.

A box beam, or girder, constructed of plates of wrought iron, compared to a single rib and flanched beam **I**, of equal weights, has a resistance as 100 to 93.

The resistance of beams, or girders, where the depth is greater than their breadth, when supported at top, is much increased. In some cases, the difference is fully one-third.

When a beam is of equal thickness throughout its depth, the curve should be an ellipse, to enable it to support a uniform load with equal resistance in every part; and if the beam is an open one, the curve of equilibrium, for a uniform load, should be that of a parabola. Hence, when the middle portion is not wholly removed, the curve should be a compound of an ellipse and a parabola, approaching nearer to the latter as the middle part is decreased.

Girders of Cast Iron, up to a span of 40 feet, are cheaper than of wrought iron.

Cast iron beams and girders should not be loaded to exceed one-fifth of their breaking weight, and when the strain is attended with concussion and vibration, this proportion must be increased, and they should not be subjected to a deflection exceeding the ·05ths of their length, or to a test much exceeding the greatest stress to which they are to be subjected.

Simple cast iron girders may be made 50 feet in length, and the best form is that of Hodgkinson: when subjected to a fixed load, the flanch should be as 1 to 6, and when to a concussion, &c., as 1 to 4.

The forms of girders for spaces exceeding the limit of those of simple cast iron, are various; the principal ones adopted are those of the straight or arched cast iron girders in separate pieces, and bolted together, the trussed, the bow string, and the wrought iron box and tubular.

The *Straight* or *Arched girder* is formed of separate castings, and is entirely dependent upon the bolts of connexion for its strength.

The *Trussed* or *Bow String girder* is made of separate castings on a single piece, and its strength depends, other than upon the depth or area of it, upon the proper adjustment of the tension, or initial strain, upon the wrought iron truss.

The *Box* or *Tubular girders* are made of wrought iron, and are best constructed with cast iron tops, in order the best to resist compression: this form of girder is best adapted to afford lateral stiffness.

## Floor Beams, Girders, &c.

The condition of the stress borne by a Floor Beam is that of a beam supported at both ends and uniformly loaded; but from the irregularity in its loading and unloading, and from the necessity of its possessing great rigidity, it is impracticable to estimate its capacity other than as a beam, having the weight borne upon the middle of its length.

*To Ascertain the Depth of a Floor Beam, the Length and Breadth being Given.*

*When the distance between the Centres of the Beam is One Foot.*

Rule.—Divide the product of the square of the length in feet and the weight to be borne in pounds per square foot of floor, by the product of four times the breadth and the *value* of the material from the preceding table (page 387), and the square root of the quotient will give the depth of the beam, in inches.

Example.—A white pine beam is 2 inches wide and 12 feet in length between the supports; what should be the depth of it to support a weight of 175 lbs. per square foot?

$$\frac{12^2 \times 175}{2 \times 4 \times 30} = 105, \quad \text{and } \sqrt{105} = 10{\cdot}25 \textit{ ins.}$$

*When the Distance between the Centres of the Beam is greater or less than one foot.*

Rule.—Divide the product of the square of the depth for a beam, *when the distance between the centres is one foot*, by the distance given in inches by 12, and the square root of the quotient will give the depth of the beam in inches.

Example.—Assume the beam in the preceding case to be set 15 inches from the centres of its adjoining beams; what should be its depth?

$$\frac{10{\cdot}25^2 \times 15}{12} = 131{\cdot}25, \quad \text{and } \sqrt{131{\cdot}25} = 11{\cdot}45 \textit{ ins.}$$

*Headers and Trimmer Beams.*—The conditions of the stress borne or to be provided for by them, in floors, are as follows:

*Headers or Trimmers*—Support one-half of the weight of and upon the tail beams inserted into or attached to them.

*Trimmer Beams*—Support, in addition to that borne by them directly as a floor beam, each one-half the weight on the headers.

*Hence*, The stress on a header is due directly to its length, or the number of tail beams it supports; and the stress on the trimmer beams is due to the half of the weight on the header supported by them.

NOTE.—The distance between the support of the trimmer beams and the point of connexion with the header, does not in any wise affect the stress on the trimmer beams; for in just proportion as this distance is increased, and the stress upon them consequently increased by the suspension of the header from them nearer to the middle of their length, so is the area of the surface supported by the header reduced, and, consequently, the load to be borne by it.

*Girder.*—The condition of the stress borne by a Girder is that of a beam fixed or supported at both ends, as the case may be, supporting the weight borne by all of the beams resting thereon, at the points at which they rest; and its dimensions must be proportionate to the stress upon it, and the distance between its points of insertion or support.

ILLUSTRATION.—It is required to determine the dimensions of a pitch pine girder, 15 feet between its several points of supports,* to support the ends of two lengths of beams each 20 feet in length, having a superincumbent weight, including that of the beams, of 200 pounds per square foot.

The condition of the stress upon such a girder would be that of a number of beams, 40 feet in length ($20 \times 2$), supporting at both ends and loaded uniformly along their length, with 200 lbs. upon every superficial foot of their area.

*Hence*, The amount of the weight to be borne is determined by $20 \times 2 \times 15 \times 200 = 120{,}000$ *lbs.* = *the product of twice the length of a beam, the distance between the supports of the girder and the weight borne per square foot of area*, and the resistance to be provided for is that to be borne by a beam, 15 feet in length, fixed at both ends, and supporting 120,000 lbs. uniformly laid along its length, equal to 60,000 lbs. supported at its centre.

*Consequently*, $\dfrac{15 \times 60{,}000}{6 \times 50} = 3000$ = *quotient of the product of the length and weight ÷ the product of 6 times the Value of the material;* and assuming the girder to be 12 inches wide, then,

$$\sqrt{\frac{3000}{12}} = 15{\cdot}8 \text{ ins., the depth required.}$$

(To be Continued.)

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## *Professor Way's Electric Light.*

From the Lond. Engineer, No. 245.

The passengers over the Hungerford Suspension Bridge, and on the Lambeth strand, on Monday evening last, were enabled to witness the effect of the electric light invented by Professor Way; the brilliant flood from which issued from a window on the north side of the river, bringing into startling relief every object it encountered. This light differs in character from that produced through electrical agency by

* When a girder has four or more supports, its condition is that of a beam fixed at the ends.

means of charcoal points, and from the lime-light, principally in its great volume, appearing, not as a single vivid point, but as a focus of considerable dimensions. It is of an intense white color, with a tinge of green. The effect of its intermission was very striking; the glare of broad daylight being suddenly exchanged for darkness, rendered visible by the moon looking unusually dim and red by the effect of the contrast. Proceeding to the *locale* whence issued the illumination, the arrangements were kindly explained by Mr. Thomas Evans, who had charge of the apparatus, and subsequently by the Professor himself, and we are thus enabled to afford our readers some information respecting the arrangements for producing this light, concerning which little is generally known. A fine stream of mercury, which can be regulated according to the battery power and the volume of light required, passes from an upper into a lower reservoir, and is made to conduct the electric current, by means of which it becomes intensely heated and partly dissipated in vapor. The vaporized mercury becomes subsequently condensed, and proceeds to the lower reservoir, whence it again issues, when the upper reservoir is exhausted and the apparatus reversed. The evolution of light by the passage of the electricity through the fluid conductor appears, however, to be due, not alone to the heating effect, but also, as in the case of the light from charcoal points, to the intensity of the current employed. This fact, which is of interest in explaining the phenomenon which takes place, was pointed out to us by Mr. Fuller, the electrician of the Silvertown Telegraph Cable Works, and was confirmed by an examination of the battery employed, which, contrary to our anticipation, was an *intensity* rather than a *quantity*, or heating arrangement. The employment of the mercury stream, as a conductor, fulfils conditions which would probably be wanting in any other substance which could be used for the purpose of obtaining light by similar means. Thus, although some illuminating effect may be produced by heating platinum wire to whiteness by a quantity current, this conductor is deficient in those characters which enable us, by means of tension electricity, to obtain light from charcoal points, interrupted metallic conductors, and the mercury stream of Professor Way. If, on the other hand, we interrupt the wire, we obtain the electric spark which appears in making and breaking contact with mercury; but we fail to produce the heating effect upon the conductor, to which the illuminating power is partly due in the arrangement under notice. It is obvious, moreover, that the constant renewal of the conductor renders it possible to employ a current of any degree of power, and which would be otherwise inadmissible. The vertical mercury stream must be considered as composed of a multitude of conducting globules separated by an imperceptible interval, and thus affording the vivid spark which occurs in making and breaking contact with the metal. This hypothesis affords an explanation of the fact, that an equal illuminating effect cannot be obtained with a *horizontal* stream of mercury, although the latter may be heated to an equal degree. It should be observed, that the apparatus of Prof. Way, which may probably before long be employed in light-houses and

for signalling, is rendered air-tight, so as to preclude the possibility of any injurious effect arising from escape of the vaporized mercury.

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Translated for the Journal of the Franklin Institute.

*Note relative to the Mathematical Expression for the Mechanical Equivalent of Heat.* By M. DESPRELS, Major of 11th regiment of Artillery.—*L'Institut*, October, 1860.

A dynamic theory of heat according to the ideas of Mongolfier as to the identity of heat and motion, tends to cause this agent to be considered as the expression of the movement of particles of common matter; the moving force or work of which, is capable of being communicated, while being reduced, as the velocity of a fall of water is reduced or even destroyed, after having communicated to the hydraulic machine an amount of work equal to one-half of the moving force which has disappeared.

In this theory the mechanical equivalent of heat is defined to be the quantity of work which an unit of heat can thus produce as it disappears, or reciprocally, the quantity of work, which while being apparently destroyed, will produce an unit of heat. The determination of this quantity has been the object of the experiments of various savans and especially of M. Joule, who has estimated its value at 424 kilogrammetres; the heat necessary to raise 1 kilogramme of water from 0° to 1°, being taken as unity.*

I hoped to reach an analytical expression for this quantity, by reasoning in the following way:

Let us consider any elastic fluid at the temperature 0°.

Let us establish the following notations:

$E =$ the mechanical equivalent of 1 calory in kilogrammetres.

$\alpha =$ the co-efficient of dilatation of the fluid under consideration.

$P =$ the pressure in kilogrammes, of the fluid upon 1 metre square.

$\delta =$ the weight in kilogrammes, of a cubic metre of the fluid.

$c =$ the quantity of heat necessary to raise 1 kilogramme of the fluid from 0° to 1°; the pressure remaining constant.

$c' =$ the quantity of heat necessary to raise 1 kilogramme of the fluid from 0° to 1°; the volume remaining constant.

$k = \frac{c}{c'} =$ the ratio of these preceding quantities.

Let us consider 1 kilogramme of this fluid enclosed in a cylinder of a pump which is a non-conductor of heat; having for its base $\frac{1}{\delta}$, and therefore, for its height, 1 metre, from the bottom of the cylinder to the piston.

If we raise the temperature of the fluid 1°, without changing the pressure $P$, it will dilate, and (neglecting the friction) the piston will move through a space $= \alpha$. The work thus done will evidently be equal to $\frac{P\,\alpha}{\delta}$.

* The quantities used in this article are all expressed in French measures, and in Centigrade degrees.

This rise of the temperature has been produced by the heat $c$; this same quantity of heat divided by $k$, would have been sufficient to have raised the temperature of the fluid 1°, if the piston had been unmoved, that is if there had been no production of work. Moreover, in either case, although the pressures are different, the fluid at 1° contains the same quantity of heat $\frac{c}{k}$ above that which it had at 0°. In fact it would always be easy to bring it from one pressure to the other without for a single instant changing the quantity of heat which it contains; for this purpose it would be sufficient to dilate or compress it, adding or withdrawing every instant, quantities of heat having for their equivalents, the successive differential elements of the work due to the dilatation or compression. Such additions or subtractions would not at all change the quantity of heat before contained in the fluid, since they would just compensate the heat which disappeared or was produced, by the effect of the dilatation or compression.

The production of work, which has been shewn in raising the temperature of the fluid one degree, has therefore been accompanied by a loss of heat represented by $c - \frac{c}{k}$; a quantity whose mechanical equivalent is the work $\frac{\text{P}\,a}{\delta}$. The equivalent (E) of one *calory* will then be represented by the expression

$$\text{E} = \frac{\frac{\text{P}\,a}{\delta}}{c - \frac{c}{k}} = \frac{\text{P}\,a\,k}{\delta\,c\,(k-1)} \qquad (a)$$

The co-efficient $k$ is unknown, but it may be deduced from the value of another co-efficient from which it differs very little. This other co-efficient, which I shall designate by $k'$, when diminished by unity, represents the increase or depression of temperature of a fluid mass at $t°$, by the effect of a compression or dilatation of its volume equal to $\frac{a}{1 + a\,t}$. It enters as a factor into the equation which represents the velocity of sound in a fluid $\text{V} = \sqrt{g\,h\,\frac{\Delta}{\delta}\,k'\,(1 + a\,t)}$; in which $g$ represents gravity, $h$ the height of the mercurial barometer, $\frac{\Delta}{\delta}$ the ratio of the densities of mercury and the fluid. The value of $k'$ may thus be easily determined by the measurement of the velocity of sound in the fluid; it was thus directly determined, but for air only, by an experiment of Clement and Desormes.

The signification of the co-efficient $k'$ may be determined in another way. In fact, if we heat through $k'$ degrees, under constant volume, a fluid mass at $t°$, its temperature will become $(t + k')°$, and its pres-

sure will be increased; if we then dilate it by a fraction of its volume $= \frac{a}{1 + a\,t}$, it will, from the definition of $k'$, undergo a cooling equal to $k' - 1$, and its temperature becoming $t + 1$ will correspond then to its primitive pressure. It may therefore be said, that $k'$ represents the number of degrees by which the temperature of a fluid must be increased, under constant volume, in order that when it afterwards expands to its primitive pressure, this increase of temperature shall be reduced from $k'$ to $1°$.

When the fluid mass is 1 kilogramme, its specific heat $c$ under constant pressure is necessarily a little less than the quantity of heat $c'\,k' = c\,\frac{k'}{k}$ necessary to raise its temperature $1°$, in the method indicated; a method which evidently implies a greater quantity of work done.* Let us endeavor to express the value of this work, in order to deduce from it the value of $k$.

Let us as before, suppose 1 kilogramme of fluid at 0°, enclosed in a cylinder whose section $= \frac{1}{\delta}$ with a height of 1 metre. Increase the temperature of this fluid by $k'$ degrees, under constant volume, and then let it fall from $k'$ to $1°$, by a dilatation $a$.

Let $x$ be a variable quantity between $1$ and $1 + a$, representing the distance of the piston from the bottom of the cylinder during the expansion.

Let $t°$ be the temperature of the fluid corresponding to the distance $x$ and variable from $k'$ to $1$.

The work done by the expansion will evidently be

$$\frac{\mathrm{P}\,a}{\delta}\int_{x=1}^{x=1+a} \frac{1 + a\,t}{x}\,dx.$$

The variable $x$ being comprehended between the very narrow limits $1$ and $1 + a$, the expression under the integral sign may be replaced by the mean of its extreme values $\left(1 + a\,\frac{k'}{2}\right)d\,x$. The work done will then be $\frac{\mathrm{P}\,a}{\delta}\left(1 + a\,\frac{k'}{2}\right)$.

* The error which was formerly committed in the interpretation of the experiment referred to, and consequently in the signification of the coefficient adopted to modify the formula by which Newton had expressed the velocity of sound, through a fluid, consists in the confounding (which was at that time inevitable) of the quantities of heat $c$ and $c\,\frac{k'}{k}$. This error cannot be in the equality of the specific heats under constant pressure, and under constant volume; for if it is, as I have above shewn, correct to say that the heat *contained* in the same fluid mass raised from 0° to 1° under constant pressure and under constant volume, is the same; yet it is equally true to add that the heat *received*, that is to say necessary to produce similar effects, are essentially different. It is in this latter sense that I have defined $c$ and $c'$. The error of the interpretation of the experiment exists therefore not in the words only but in fact. In fact $k$ and $k'$, quantities nearly equal but theoretically different, have been confounded: $k$ represents $\frac{c}{c'}$, and $k'$ may be put under the form $\frac{c''}{c'}$, $c''$ representing the heat which it is necessary to give, under constant volume, to 1 kilogramme of an elastic fluid at 0°: in order that, in afterwards expanding to its primitive pressure, that is by a fraction $a$ of its volume, its temperature may be carried from 0° to 1°.

This is evidently a little greater than the work $\frac{\text{P}\,a}{\delta}$ which accompanies the action of the specific heat under constant pressure.

Dividing this work by the loss of heat $= \frac{c}{k}(k' - 1)$ which it caused, the mechanical equivalent of a calory will again be obtained.

Referring then to the equation ($a$) we shall have:

$$\frac{\frac{\text{P}\,a}{\delta}\left(1 + a\frac{k'}{2}\right)}{\frac{c}{k}(k' - 1)} = \frac{\text{P}\,a\,k}{\delta\,c\,(k - 1)}$$

when we conclude
$$k - 1 = \frac{k' - 1}{1 + \frac{a\,k'}{2}} \qquad (a)$$

and consequently
$$\text{E} = \frac{\text{P}\,a\,k'\left(1 + \frac{a}{2}\right)}{\delta\,c\,(k' - 1)} \qquad (b)$$

If I apply this formula to the atmospheric air, assuming the velocity of sound at 0° equal to 333 metres, and assuming with M. Regnault, for the co-efficient of dilatation, the specific heat and the weight of air and of mercury, the following numbers,

$$a = 0{\cdot}00367\,;\ c = 0{\cdot}23741\,;\ \delta = 1{\cdot}293187\,;\ \Delta = 13595{\cdot}93 = \frac{\text{P}}{0{\cdot}76},$$

I obtain, $k' = 1{\cdot}41485$. $\text{E} = 422{\cdot}03$ kilogrammetres.

This value of the mechanical equivalent of heat does not differ by a very notable quantity from the results of direct experiments, which appear to be grouped around the value 424 kilogrammetres.

The formula ($b$) moreover must give a value of this quantity affected by slight inaccuracies which may yet affect the determination of its factors. It appears to establish a natural connexion between these various quantities destined to control each other, and mutually to rectify each other, by means of the experiments, of which each one of them may have been or may become the object.

The correctness of the number adopted for the velocity of sound especially, exercises a preponderating influence on the precision of the value of the mechanical equivalent. Thus by admitting, in accordance with an experiment of MM. Bravais and Martins, the number 332·37 m. in place of 332 m. for the velocity of sound at 0°, we obtain 425·92 in place of 422·03 kilogrammetres for the mechanical equivalent of heat.

The following table gives the values of the mechanical equivalent of heat (E) deduced from the formula ($b$) applied to various gases, assuming for $k'$ the values generally admitted, and for $\delta$, $c$ and $a$ the results of the experiments of M. Regnault.

| Gas. | $a$. | $\delta$. | $c$. | $k'$. | E. |
|---|---|---|---|---|---|
| Air, | 0·00367 | 1·293187 | 0·23741 | 1·421 | 417·67 |
| Oxygen, | 0·00367 | 1·429802 | 0·21751 | 1·415 | 416·54 |
| Hydrogen, | 0·003661 | 0·089578 | 3.4090 | 1·407 | 429·03 |
| Carbonic Acid, | 0·00371 | 1·977414 | 0·20246 | 1·338 | 379·75 |

Deducing directly the values of $k'$ from the velocities of sound (V) in these different gases, I obtained other results as below:

| | Air. | Oxygen. | Hydrogen. | Carbonic acid. |
|---|---|---|---|---|
| Values of V, | 333· | 317·17 | 1269·50 | 261·60 |
| " $k'$, | 1·41485 | 1·419128 | 1·424393 | 1·32980 |
| " E, | 422·03 | 412·69 | 416·21 | 387·66 |

The reasoning which led to the formulæ ($a$) and ($b$) would be exactly applicable to a fluid passing from the temperature $t$ to the temperature $(t + 1)$. For that purpose it will be sufficient for gases, under the law of Mariotte, to replace $a$ by $\frac{a}{1 + a\,t}$. If the gas considered, departs from this law, it would be necessary to replace $a$ by another notation $a_t$, which should represent the increase of volume of the fluid passing from $t°$ to $(t + 1)°$ without change of pressure. We should thus obtain more general expressions, capable of connecting together the variations of their consecutive factors for the variations of temperature.

The considerations on which all these formulæ rest, assume that the heat which has disappeared has all been converted into mechanical work. But it may happen otherwise, and nothing opposes our admitting that in certain cases a portion of the heat is absorbed in molecular work not capable of being at once transformed into mechanical work. In such a case the formula ($b$) could no longer represent the absolute invariable value of the equivalent of heat but only the value of an equivalent dependent on the medium through which the heat acts. Recent experiments of M. Regnault (as yet, I believe, unpublished) seem to indicate that this is the case with gases near their points of liquefaction, and that the value of the equivalent may in such a case vary by nearly $\frac{1}{5}$ of its value in gases of a more permanent character. It is undoubtedly to causes of this kind that we must attribute the low values of E, in carbonic acid, a liquefiable gas. I regret that I have not been able to obtain data sufficient for the application of my formula to other gases near their point of liquefaction.

The formula ($a$) by determining the quantity $k$, permits us to calculate the quantity of heat which a gas contains at a certain temperature; it also gives us the means of calculating the quantity of heat absorbed by a fluid heated through $t°$, when both its volume and pressure change.

This problem is indeterminate;* but in each particular case, it is susceptible of a solution expressed in a function of the mechanical equivalent of heat.

Let us conceive a vertical cylinder of 1 square metre in base, containing in its lower part, whose height is L, a weight Q of an elastic fluid at the temperature $\theta$, and in its upper part, whose height is H, a weight of water equal to 1000 H; these two parts being separated by a piston, whose weight, thickness, and friction, I will neglect. Suppose this cylinder to be surmounted by a vessel whose height is H′, open at its two extremities and capable of holding the volume of water assumed above. Let us heat the fluid, permitting it to expand freely under the variable pressure which it supports, so that when its temperature shall be $t°$, it occupies the whole capacity of the cylinder, having driven out all the water into the upper vessel. Let $h$ be the distance of the centres of gravity G and G′ of the water in its extreme positions, in the cylinder and in the vessel.

The pressure of the elastic fluid at the beginning of the motion is necessarily supposed equal to the atmospheric pressure (P) increased by 1000 H. When the piston has reached the end of its course, at the top of the cylinder, this pressure will be equal to P + 1000 H′, the height H′ being invariably determined in a function of $t$, from the equation,

$$\frac{\mathrm{L}\,(1+a)\,(\theta+t)\,(\mathrm{P}+1000\,\mathrm{H})}{(1+a\,\theta)\,(\mathrm{P}+1000\,\mathrm{H}')}=\mathrm{L}+\mathrm{H}.$$

The work done, when the liquid has all passed into the upper vessel, will be $= \mathrm{P\,H} + 1000\,\mathrm{H}\,h$; and the heat which has disappeared, in the production of this work, will be evidently equal to

$$\frac{1}{\mathrm{E}}\,(\mathrm{P\,H}+1000\,\mathrm{H}\,h).$$

E representing the mechanical equivalent of the heat, absolute or relative according to the nature of the fluid; as in formula ($b$).

On the other hand the fluid at the temperature $(\theta+t)°$, contains, in addition to that which it had at the temperature $\theta°$, a quantity of

heat $= \dfrac{\mathrm{Q}\,c\,t}{k}$, which, according to the formula ($a$) $= \dfrac{\mathrm{Q}\,c\,t\left(1+k'\,\frac{a}{2}\right)}{k'\left(1+\frac{a}{2}\right)}$

The whole quantity of heat received by the fluid will then be $=$

$$\frac{\mathrm{Q}\,c\,t\left(1+k'\,\frac{a}{2}\right)}{k'\left(1+\frac{a}{2}\right)}+\frac{1}{\mathrm{E}}\,(\mathrm{P\,H}+1000\,\mathrm{H}\,h).$$

This equation is indeterminate, for without changing either the heat

* My attention was called to this problem by reading the following passage in the "*Cours de Physique de l'Ecole Polytechnique*" by M. Jamin, Vol. 2d, page 355.

"It would moreover be necessary, that we should be able to calculate the heat absorbed when a weight P of a gas is heated through $t°$, its volume and pressure both changing. These are questions of which recent investigations have shewn the complexity, and which have not yet been solved.

or the expansion of the gas, and consequently without changing the level of the liquid after its ascent, we may, by changing the form of the vessel, vary the position of the centre of gravity of the liquid raised, the work to be done, and therefore the heat which will disappear. In each particular case it must be solved by dividing the integral of the elementary works done, by the mechanical equivalent of heat, absolute or relative according to the nature of the fluid, and adding to this fraction the excess of heat which the fluid really contains in consequence of its heating.

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For the Journal of the Franklin Institute.

## *Particulars of the Clipper Ship Garibaldi.*

Hull built by Messrs Maxson, Fish & Co., Mystic, Conn. Owners, Messrs. Calvin Adams & Co., City of New York. Commander, Capt. Edward Adams. Intended service, from New York to Liverpool.

Hull.—Length of keel, 178 ft. Do. of main deck, 193 ft. Do. over all, 200 ft. Breadth of beam at midship section, 40 ft. Depth of lower hold, 14 ft. Do. between decks, 9 ft. Do. of poop deck, 6 ft. 8 ins. Do. of half deck, from poop forward, 4 ft. 8 ins. Keel, 15 × 24 ins. Floors, molded, 17 ins. Very heavy frame, two-thirds white oak, and one-third white chestnut. Bottom planks, 4 inches thick; side do. 5 ins. thick; all of oak. Keelsons, 5 ft. high, of yellow pine. Bilge streaks, 12 ins., diminishing to 10 ins; at top, 11 ins. Hanging knees (oak), 12 ins. amidship, but diminishing to 8 ins. Five heavy hooks and pointers forward, and three aft, in lower hold. Lower deck beams, 15 × 24 ins. Main deck beams, 15 × 11 ins. Patent windlass for 2 in. chain. Tonnage, 1195 tons.

Masts.—Foremast, 33 ins. diameter, 77 ft. long; main do., 34 ins. do., 79½ ft. do.; mizen do., 26 ins. do., 73 ft. do. Fore-topmast, main do., topgallant, and royal masts, each 16 ins. diameter, 45 ft. long. Bowsprit, 28 ins. diameter.

Yards.—Lower yards, topsail do., topgallant do., royal do., each 16 ins. diameter, 45 ft. long.

Distance from knightheads to centre of foremast, 42 ft.; from thence to centre of mainmast, 64 ft.; do. do. mizenmast, 48 ft.; do. taffrail, 45 ft. Rudder-stock, 18 ins. diameter. Pumps, 4—2 of 7½ ins., and 2 of 6 ins.

*Remarks.*—The materials used in the construction of this vessel were of superior quality, and the manner in which they were put together betokens excellent workmanship. She is thoroughly fastened with copper, leads, cased treenails, &c., &c., and has Long Island locust driven through and wedged inside, from keel to top. The ceiling, in addition to this, is square fastened with bolts.

Immediately after launching, the *Gairbaldi* entered the port of New York, and was there the subject of general remark among sea-cnptains, ship-owners, and others, to the effect, that the beauty of her model, the staunch and sea-worthy appearance she presented, with the superior manner in which she was finished, could not be easily excelled in a vessel of her class. Credit is justly due to Messrs. Maxson, Fish & Co., for such a successful production. E. B.

For the Journal of the Franklin Institute.

## *Particulars of the U. S. Steam Sloop-of-war Richmond.*

The *Richmond* is one of the *five sloops* ordered by Congress, and is of the same class with the *Hartford*, *Lancaster*, and *Brooklyn*.

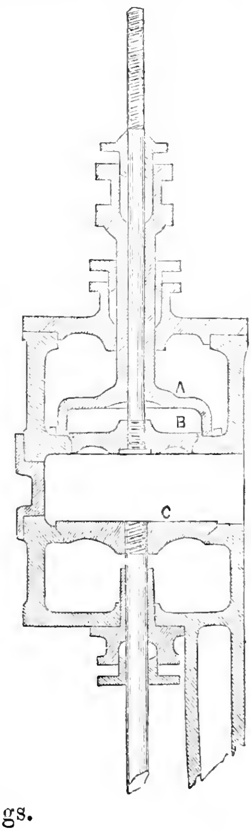
The hull was constructed in the Gosport Navy Yard by the late Samuel T. Hartt. The following are the principal dimensions:

Hull.—Length between perpendiculars, 235 ft. Do. from billet to taffrail, 259 ft. Do. for tonnage, 243 ft. Depth of hold, 12 ft. 8 ins. Draft of water, 15 ft. 6 ins. Tonnage, 2023 91-95 tons. Area of immersed section, 557 sq. ft. Displacement at 15 ft., 2382 tons. Do. at 17 ft., 2829 tons. Length of engine and boiler space, 71 ft.

The machinery was also constructed in the Gosport Yard from the designs of Samuel Archbold, Engineer-in-chief, U. S. Navy, and consists of two horizontal back-acting engines.

Diameter of cylinder, 4 ft. 10 ins. Length of stroke, 3 ft. Diameter of air pump, 19 ins. Do. of crank shaft, $12\frac{1}{2}$ ins. Do. of screw shaft, 12 ins. Maximum pressure of steam, 25 lbs. Do revolutions, 45.

The engines are fitted with a peculiar arrangement of valves connected with Sickle's improved "cut-off." There are three valves upon each end of the cylinder as shown in the annexed diagram. The main steam valve A is made in a cup-form to allow the cut-off valve B to rise whilst the valve A remains in its seat; thus permitting the cut-off valve to be set considerably in advance of the steam valve. C is the exhaust valve. As the valves are now set, the main valve has about $\frac{9}{16}$, the cut-off valve $1\frac{7}{8}$, and the exhaust valve 2 inches lead. The valves are operated by a species of link-motion, so arranged that when the link is in mid position both rock-shaft pins are disconnected and the valves closely seated. This apparatus works very well, but the quantity of machinery required, the complication, and number of moving parts, afford a very serious objection and detract very much from the practical value of an adjustable cut-off.




The cylinders are fitted with steam jackets. The main brasses are chambered to admit a continuous stream of water passing through without coming in contact with the journals.

The crank and screw shafts are coupled with a wrought iron universal coupling, which will allow considerable deviation of the shaft from a straight line without affecting the engines. The screw shaft is fitted with both the collar and cone thrust bearings, and that part of the shaft passing through the dead-wood is cased with brass, and works upon lignum vitæ bushings.

BOILERS.—Three of Martin's vertical tubular boilers. One of these constitutes the "donkey," and consists of a single furnace, but which may be used at any time in connexion with the main boilers.

Length of boilers, 10 ft. 8 ins. Breadth of do., 21 ft. 6 ins. Height of do., exclusive of steam chimney, 10 ft. 9 ins. Do., inclusive of do., 12 ft. 9 ins. Total number of furnaces, 13. Width of do., 3 ft. Length of grates, 6 ft. 6 ins. Total number of tubes, 3900. Length of do., 2 ft. 8 ins. External diameter of do., 2 ins. Total grate surface, 253 sq. ft. Total heating do., 7272 sq. ft. Diameter of smoke pipe, 6 ft. 6 ins. Height of do. above grates, 50 ft. Area of do., 33·18 sq. ft. Least area between tubes, 46·22 sq. ft.

SCREW.—Brass.—Diameter of screw, 14 ft. Length of do., 3 ft. 6 ins. Pitch of do., 25 ft., expanding to 28 ft. Number of blades, two. Weight, 11,820 lbs.

The forward edge of the screw near the periphery is considerably cut away, whilst the after edge is nearly square.

Armament.—Sixteen 9-inch shell guns; total weight of battery 145,155 lbs. or 64·8 tons; two 12-pounder boat howitzers.

Performance.—The run from Gibraltar to Spezzia, Sardinia, a distance per log of 909 miles, was made in four days and three hours—making an average of 9 knots per hour. Under steam alone 8 knots, but with steam and sail, with a moderate breeze, 11 to 11·5 knots. Average number of revolutions per minute, 42, and 15 lbs. of steam with an average consumption of 1920 lbs. of coal per hour.

J. H. W.

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For the Journal of the Franklin Institute.

## *Transverse Strain of Materials.*

The object of the present investigation is to demonstrate a mode of experiment by which the relative powers of any flexible material to resist compression and extension by transverse strain, may be exactly ascertained.

Take two prisms of the same material, of equal length, and let them have the same cross section, viz: an isosceles triangle, whose base is equal to its altitude; and having placed them on supports equal distances apart, the one with the vertex of the triangle up, the other down,—note exactly the amount of deflection which equal weights applied at their centres will produce in each: if the deflections produced in each by equal loads are equal, then the powers of the material to resist compression and extension will be equal, under that load.

If the deflections vary, then the power of resistance to compression is the greater when the deflection of the prism loaded with its vertical line up is less than for the one with its base uppermost, and *vice versa.*

To find the proportion which the power to resist compression bears to the power to resist extension, when the former is the greater: let $a$ be the deflection when the base is up, and $a_{\prime}$ the deflection when it is down; then divide $a_{\prime}$ by $a$, and seek for the number corresponding to the quotient in the column headed $\frac{a_{\prime}}{a}$ of the following table; directly opposite to it, in the column headed $x$, will be found the number

corresponding to the ratio, which the power to resist compression bears to the power to resist extension, for that load.

| $x$ | $\frac{a_{\prime}}{a}$ | $x$ | $\frac{a_{\prime}}{a}$ | $x$ | $\frac{a_{\prime}}{a}$ |
|---|---|---|---|---|---|
| 1· | 1· | 3· | ·8694 | 5 | ·81873 |
| 1·2 | ·9804 | 2·4 | ·9073 | 5 | ·8347 |
| 1·4 | ·9626 | 2·6 | | | |
| 1·6 | ·949 | 2·8 | ·8910 | | |
| 1·8 | ·936 | 3· | ·8845 | 6 | ·8258 |
| 2· | ·9140 | 4· | ·8385 | 6 | ·8100 |

NOTE.—This table can be made out for every 1-10th without much trouble. Before using it, it should be verified and so extended.

For example, let two prisms with equal loads give

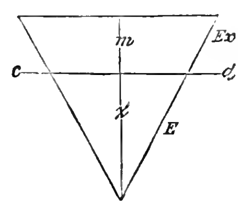
 With vertical line of pressure up $a$ and

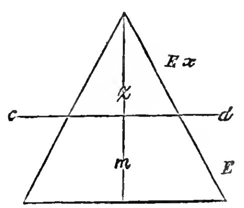
 With do do down $a_{\prime}$

for their deflections, and let $\frac{a_{\prime}}{a} = {\cdot}949$; then the power of resistance of their material to compression, is 1·6 times their power of resistance to extension.

But should $a$ prove less than $a_{\prime}$, and suppose $\frac{a}{a_{\prime}} = {\cdot}949$; then the power of the material to resist extension would be 1·6 times its power to resist compression.

To explain the manner in which the column $\frac{a_{\prime}}{a}$ may be obtained.




Let the triangles represent the cross sections of the two prisms:

Let $h$ = their altitude = their base.

$z$ and $z_{\prime}$ = the distances from the vertices to $c\ d$.

$m$ and $m_{\prime}$ = the distances from the bases to $c\ d$.

$x$ = the ratio which the power to resist compression bears to the power to resist extension.

The line $c\ d$ being the dividing line between the part of the triangle compressed and the part extended.

Let $E$ = the modulus of elasticity of the material to resist extension,

and $Ex$ = the modulus of elasticity to resist compression—taking the modulus of elasticity in the sense that Weisbach does in his Mechanics, vol. i, chap. 6.

Now, as the basis of the whole we have,

$$\int (h - m - z)\, z^2\, d\, z = \int (z + m)\, m^2\, d\, m.$$

From this we obtain the moments of flexure.

(A) $\left(\left(\frac{h\, z^3}{3} - \frac{m\, z^3}{3} - \frac{z^4}{4}\right) + \left(\frac{z\, m^3}{3} + \frac{m^4}{4}\right) x\right) E$, where the vertex is down, and

(B) $\left(x\left(\frac{h\, z_{\prime}^3}{3} - \frac{m\, z_{\prime}^3}{3} - \frac{z_{\prime}^4}{4}\right) + \left(\frac{z\, m_{\prime}^3}{3} + \frac{m_{\prime}^4}{4}\right)\right) E$, where the vertex is up.

And we have also the equations,

(1) $$E\left(\frac{h\, z^3}{3} - \frac{m\, z^3}{3} - \frac{z^4}{4}\right) = \left(\frac{z\, m^3}{3} + \frac{m^4}{4}\right) E x, \quad \text{and}$$

(2) $$E x\left(\frac{h\, z_{\prime}^3}{3} - \frac{m_{\prime} z_{\prime}^3}{3} - \frac{z_{\prime}^4}{4}\right) = \left(\frac{z_{\prime}\, m_{\prime}^3}{3} + \frac{m_{\prime}^4}{4}\right) E.$$

Making $h =$ unity, we find from these two equations,

(3) $$z^4 - \frac{6\, z^2\, x}{x+1} + \frac{8\, z\, x}{x+1} - \frac{3\, x}{x+1} = 0, \quad \text{and}$$

(4) $$z^4 - \frac{6\, z_{\prime}^2}{x+1} + \frac{8\, z_{\prime}}{x+1} - \frac{3}{x+1} = 0.$$

Now, from equations (3) and (4), by giving to $x$ the successive values 1·2, 1·4, 1·6, &c., we can find the corresponding values of $z$ and $z_{\prime}$.

Now, by taking from Weisbach as before, § 190, the equation $a = \frac{P\, l^3}{8\, W E}$.

Next, from the moments of flexure (A) and (B), we have

$$W = \frac{z^4}{12} + \left(\frac{z}{3} + \frac{m}{4}\right) m^3\, x = \frac{z^4}{6}, \quad \text{and}$$

$$W_{\prime} = x\frac{z_{\prime}^4}{12} + \left(\frac{z_{\prime}}{3} + \frac{m_{\prime}}{4}\right) m_{\prime}^3 = \frac{z_{\prime}^4\, x}{6}.$$

From these data, the $E$ equation,

$$\frac{z^4}{x\, z_{\prime}^4} = \frac{a_{\prime}}{a},$$

is at once found, and

$$E = \frac{3\, P\, l^3}{8\, z^3\, a} = \frac{3\, P\, l^3}{8\, z_{\prime}^3\, a_{\prime}\, x}.$$

The suitable dimensions for samples to be experimented on, are

probably from four to six feet long for a cross section of 7 inch base to the triangle.

In making experiments on a pair of samples, the following was the mode of recording the deflections adopted:

| Name of Material. | Deflections in inches produced by the weights marked at the head of each column. | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | lbs. 7½. | lbs. 12. | lbs. 16½. | lbs. 21. | lbs. 25½. | lbs. 30. | lbs. 34½. | lbs. 39. | lbs. 43½. | lbs. 48. | lbs. 52½. |
| Spruce, △ | | ·06 | ·07 | ·10 | ·12 | ·13 | ·16 | ·18 | ·21 | ·23 | ·24 |
| do, ▽ | | ·06 | ·09 | ·11 | ·13 | ·17 | ·19 | ·22 | ·25 | ·28 | ·30 |

The apparatus used in these experiments was too clumsy to afford satisfactory results, and their lengths compared with their cross sections were too short: they were 2 feet long, and had 1 inch for the base of their triangle.

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Translated for the Journal of the Franklin Institute.

## *Method of Disinfecting Mouldy Casks.* By M. Chetelain.

The casks are first washed out for about five minutes with an alkaline solution of soda, and are then soaked for one or two days with a liquor acidulated with hydrochloric acid.

The Committee of the Society for the Encouragement of National Industry report that the process is effective both for wine and beer casks; that it is cheap; and saves great expense.—*Bull. Soc. Encour. l'Indust. Nat.*, May, 1860.

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# AMERICAN PATENTS.

### AMERICAN PATENTS ISSUED FROM NOVEMBER 1, TO NOVEMBER 30, 1860.

| | | | | |
|---|---|---|---|---|
| Air Engines, . | Stephen Wilcox, Jr., . | Westerly, | R. I. | 20 |
| ———— . | " | " | " | 20 |
| Amalgamator, . | Woodworth & Wethered, | San Francisco, | Cal. | 27 |
| ———— . | Wyckoff & Fell, | Brooklyn, | N. Y. | 27 |
| Apple and Potato Parer, . | Clewell, Jr., & Schatz, | Nazareth, | Penna. | 20 |
| Aural Instruments, | C. G. Page, . | Washington, | D. C. | 20 |
| Baby-jumper, couch, & carriage, | J. S. Brown, . | Green Point, | N. Y. | 27 |
| Bed Bottom,—Spring | Rosenberg & Scheuerle, | City of | " | 13 |
| Blind Fastenings, . | J. J. Henry, . | N. White Creek, | " | 27 |
| ———— | Wm. S. Kirkham, | Brantford, | Conn. | 6 |
| Blowpipe Operations,—Supports | J. B. Hyde, . | Newark, | N. J. | 20 |
| Boat into a Land Carriage, | Perry Davis, . | Providence, | R. I. | 13 |

| | | | | |
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| Bobbins,—Friction Brakes for | Truman Estes, . | N. Bennington, | Vt. | 27 |
| Bridges,—Truss . | J. L. Jones, . | St. Louis, | Mo. | 6 |
| Brush-making Machine, . | John Ruegg, . | " | " | 20 |
| Burners,—Hydro-carbon, | M. L. Collender, | City of | N. Y. | 20 |
| Burnishing Machines, . | A. M. White, . | Hartford, | Conn. | 20 |
| Calligraphs, . | Charles Thurber, | Brooklyn, | N. Y. . | 27 |
| Canal and River Locks, . | James Davies, . | Schuylkill Hav. | Penna. | 6 |
| ——— Navigation,—Chutes for | Alonzo Livermore, | Tremont, | " | 27 |
| Candles,—Moulding . | Thomas King, . | Troy, | N. Y. | 6 |
| Caoutchouc,—Vulcanization of | F. D. Hayward, . | Malden, | Mass. | 27 |
| Carpenters Clamp, . | C. L. Jones, . | Richmond, | Va. | 27 |
| Carpet Duster, . | Joseph Rolls, . | City of | N. Y. | 6 |
| Carriages,—Detaching Horses | John Davis, . | Elmira, | " | 6 |
| Cartridge Cases,—Forming | Christian Sharps, | Philadelphia, | Penna. | 13 |
| Chain Link, . | J. P. Kirk, . | Austin, | Texas, | 13 |
| Cheese,—Manufacture of | Wm. McAllister, | Gerry, | N. Y. | 13 |
| Churns, . | Nevers & Ross, . | Claremont, | N. H. | 20 |
| Clevis, . | Frederick Sigrist, | Napa co., | Cal. | 27 |
| Clocks, . | Wm. B. Barnes, . | Forestville, | Conn. | 6 |
| Clothes Sprinkler, | S. N. Davies, . | Muskegon, | Mich. | 6 |
| ——— Squeezer, . | G. D. Trumpore, . | Newark, | N. J. | 6 |
| Clothing,—Spring Hooks for | J. C. Loveland, . | Springfield, | Vt. | 20 |
| Coffee-pots, . | John Beaumont, . | Hartford, | Conn. | 6 |
| Collar for Horses,—Breast | J. G. Taylor, . | Philadelphia, | Penna. | 27 |
| Corn Balls,—Moulding Parched | Russell Arnold, . | Hartford, | Conn. | 20 |
| —— Planters, . | W. H. Addle and others, | Norristown, | Penna. | 27 |
| ——————— . | Benj. Bower, . | Millersburg, | Ohio, | 27 |
| Cotton and Corn Stalk Cutters, | G. S. Roundebush, | Natchez, | Miss. | 13 |
| ——— Seed,—Cleaning | A. J. Hardin, . | Shelby, | N. C. | 6 |
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| ——————— . | W. L. Milholen, | Centre, | Ala. | 27 |
| Coupling,—Hose . | B. Holly, . | Lockport, | N. Y. | 20 |
| ————,—Thill . | R C. Millings, . | Charleston, | S. C. | 27 |
| Cracker Machine, . | J. and J. C. Holyland, | Rochester, | N. Y. | 27 |
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| ————— . | L. B. Benton, . | Penn Yan, | N. Y. | 27 |
| ————— . | C. A. Clark, . | Bloomfield, | Iowa, | 27 |
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| ————— . | Nelson Messenger, . | Newark, | Ill. | 27 |
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| ————— . | Neidich & Girvin, . | Lancaster co., | Penna. | 27 |
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| ————— . | Robertson & Carr, . | Kingston, | Mo. | 6 |
| —————,—Cotton | Noah Rogers, . | Thomas co., | Ga. | 27 |
| ————— . | L. Stevens, . | Dover, | Ky. | 27 |
| ————— . | H. G. Street, . | Liberty, | Miss. | 27 |
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| Dough,—Raising and Kneading | George Scott, . | Steubenville, | Ohio, | 27 |
| Drill Frames, . | G. C. Taft, . | Worcester, | Mass. | 27 |
| Edge Tools,—Manufacture of | S. W. Collins, . | Canton, | Conn. | 20 |
| Electro-plating with Gold Alloys, | Archille Berthoud, | City of | N. Y. | 20 |
| Embalming Dead Bodies, | Warren Iddings, . | Warren, | Ohio, | 6 |
| Excavators, . | A. J. Bartlett, . | Romulus, | N. Y. | 13 |
| —————,—Channel . | Robert Gamble, Jr., . | Tallahassee, | Fa. | 13 |
| Fences, . | O. H. Woodworth, | U.Marlborough, | Md. | 27 |
| Fire Alarms, . | A. F. Cobb, . | Chapel Hill, | Mo. | 13 |
| ————— . | E. Ehlin, . | Boston, | Mass. | 13 |

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| Fire Arms,—Breech-loading | John Boynton, . | E. Hartford, | Conn. | 27 |
| —————————— | J. S. Reeder. . | Canton, | Ohio, | 27 |
| ————,—Revolving . | Christian Sharps, . | Philadelphia, | Penna. | 27 |
| —————————— | John Adams, . | Dalston, | Engl'd, | 6 |
| —— Escapes, . | E. B. Larchar, . | City of | N. Y. | 13 |
| ———————— . | Hugh Morohan, . | Brooklyn, | " | 13 |
| Fly Traps, . | S. S. Day, . | City of | " | 13 |
| Flood Fence, . | D. C. Wilkinson, | Sidney, | Ohio, | 6 |
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| Fractured Limbs,—Apparatus for | J. M. Pitts, . | Sumter, | S. C. | 6 |
| Fruit Jars,—Covers for . | T. B. and J. S. Atterbury, | Pittsburgh, | Penna. | 20 |
| Furnaces, . | C. F. Cory, . | Lebanon, | Ill. | 27 |
| ————,—Hot Air . | Joseph Leeds, . | Philadelphia, | Penna. | 27 |
| —————————— | Oscar Paddock, . | Watertown, | N. Y. | 27 |
| Gates,—Farm . | G. C. Bovey, . | Chillicothe, | Ohio, | 27 |
| Glass Cutters, . | Collman & Feenders, | Freeport, | Ill. | 27 |
| Gold Amalgamator, | A. K. Eaton, . | City of | N. Y. | 6 |
| —————— and Washer, | J. C. Dickey, . | Saratoga Sp'gs, | " | 20 |
| Grafting Machines, | J. W. Crawford, | Rockport, | Ind. | 13 |
| Grain Cleaning Machines, | Wm. Crotzer, . | Spruce Creek, | Penna. | 20 |
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| —————————— | S. and O. Pettibone, . | Corunna, | Mich. | 20 |
| Harness Saddle, . | T. J. Weeks, . | New London, | Conn. | 13 |
| Harrows, . | James Temple, . | Bellefonte, | Penna. | 27 |
| ————,—Cultivating . | Joseph Slocum, . | Syracuse, | N. Y. | 27 |
| ————,—Rotary | Given & Foreman, . | Sumner Hill, | Penna. | 27 |
| —————————— . | Francis Raymond, | Sandusky, | Ohio, | 27 |
| Harvesters, . | L. D. Brown, . | St. Louis, | Mo. | 20 |
| ———————— . | Frederick Landon, | Brockport, | N. Y. | 13 |
| ———————— . | Nathan Maxson, . | Wilmington, | Ohio, | 13 |
| ———————— . | S. W. Tyler, . | Greenwich, | N. Y. | 13 |
| ————,—Cutting Apparat. | W. G. Smith, . | Elizabethport, | N. J. | 6 |
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| Hawse Pipes, . | Charles Perley, . | City of | " | 27 |
| Hay, &c.,—Cutting . | T. H. and D. T. Wilson, | Harrisburg, | Penna. | 6 |
| —— and Straw Cutters, | H. R. Hawkins, . | Akron, | Ohio, | 20 |
| Heating Apparatus, . | E. L. Brown, . | Brooklyn, | N. Y. | 27 |
| Heel Shave, . | D. E. Somes, . | Biddeford, | Me. | 13 |
| Hinge, . | Adams & Peckover, . | Cincinnati, | Ohio, | 6 |
| ———,—Gate . | David Wadsword, Jr., | Nashua, | N. H. | 6 |
| ———,—Stop . | Henry Pennie, . | Buffalo, | N. Y. | 6 |
| Hoes,—Making . | Moses Depuy, . | Pittsburgh, | Penna. | 6 |
| Hoop Machines, . | S. F. Atherton, . | Fitchburg, | Mass. | 13 |
| Horse Collars, . | Briding & Maxwell, | Baltimore, | Md. | 27 |
| ——— Shoe Machine, . | John McCarty, . | Philadelphia, | Penna. | 13 |
| ——— Shoes,—Punching | C. H. Perkins, . | Providence, | R. I. | 20 |
| Hose,—India Rubber . | T. J. Mayall, . | Roxbury, | Mass. | 13 |
| Hubs of Carriage Wheels, | James Johnson, . | Garysburg, | N. C. | 20 |
| Lamps,—Vapor . | H. Wm. Dopp, . | Buffalo, | N. Y. | 13 |
| ———————— . | M. W. Dillingham, | Charlestown, | Mass. | 6 |
| ———————— . | C. E. Atherton, . | Paterson, | N. J. | 6 |
| Last Holder, . | John Dickinson, | Painesville, | Ohio, | 13 |
| Latches,—Door . | Thomas Slaight, . | Newark, | N. J. | 6 |
| Leather,—Creasing | Wm. S. Bullen, . | Indianapolis, | Ind. | 27 |
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| ——— . | Lewis Layman, . | Westfield, | N. Y. | 6 |
| ———,—Door . | Jacob Kinzer, . | Pittsburgh, | Penna. | 13 |

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| Locks,—Door . | J. E. Parker, . | W. Meriden, | Conn. | 6 |
| Looms for Weaving Hair Cloth, | Isaac Angell, . | Pawtucket, | R. I. | 13 |
| Marine Propeller, . | H. D. J. Pratt, . | Washington, | D. C. | 27 |
| Milking Stool, . | Levi Loring, . | Saco, | Me. | 6 |
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| Odometers, . | L. W. Nicholls, . | N. Brookfield, | N. Y. | 13 |
| Oils,—Trying . | J. M. Hunter, . | City of | " | 6 |
| Ordnance, . | T. J. Mayall, . | Roxbury, | Mass. | 27 |
| Packing Meats,—Buildings for | D. E. Somes, . | Biddeford, | Me. | 27 |
| Paper,—Damping | Richard Martin, . | Philadelphia, | Penna. | 27 |
| ———,—Folding . | Cyrus Chambers, Jr., | " | " | 27 |
| Pictures,—Prep. of Transparent | Gustav Wedekind, | " | " | 13 |
| Pie Crimper, . | C. A. Shaw, . | Biddeford, | Me. | 6 |
| Ploughs, . | Andrew Benkelmann, | Langford, | N. Y. | 27 |
| ——— . | T. R. Cormick, . | Cap-au-gris, | Mo. | 27 |
| ——— . | Samuel Fisher, . | W. Windsor, | N. J. | 27 |
| ——— . | T. S. and J. A. Lockhart, | Wellington, | Mo. | 27 |
| ——— . | Matheny & Barnes, | De Kalb, | Miss. | 27 |
| ——— . | J. P. Pettit, . | Cold Spring, | Ky. | 27 |
| ——— . | A. W. L. Rivers, | Midway, | S. C. | 27 |
| ———,—Cotton . | W. W. Graves, . | Fort Adams, | Miss. | 27 |
| ———,—Hillside | R. H. Ewing, . | Clives, | Ohio, | 27 |
| ———,—Mole . | J. H. Elward, . | Ottawa, | Ill. | 13 |
| ——————— . | Owen Sturdevant, | Maquon, | " | 13 |
| Plough Plates of Molten Steel, | F. F. Smith, . | Momence, | " | 20 |
| Plumb-bob, . | B. F. Chappell, . | Norwich, | Conn. | 13 |
| Preserve Cans,—Sealing . | W. W. Paddock, . | Cincinnati, | Ohio, | 6 |
| Printing Plates, &c.,—Relief | E. B. Larchar and others, | City of | N. Y. | 13 |
| Provisions,—Curing . | D. E. Somes, . | Biddeford, | Me. | 13 |
| Pumps, . | Benjamin Douglas, | Middletown, | Conn. | 6 |
| Railroad Cars,—Heaters for | Wm. Pauli, . | Alexandria, | Va. | 27 |
| ——— Chairs,—Making | David Eynor, . | Philadelphia, | Penna. | 20 |
| ——— Joints, . | J. M. Heard. . | Prairie Station, | Miss. | 13 |
| ——— Rails to Cross Ties, | S. H. Witmer, . | Cincinnati, | Ohio, | 20 |
| Rakes,—Horse . | John Chappel, . | Green, | N. Y. | 20 |
| Reaping Machines,—Mowing and | Franklin Getz, . | Amherst, | " | 6 |
| ——————,—Rakes for | J. R. Byler, . | Salisbury, | Penna. | 27 |
| Rice,—Cleaning . | S. P. Kase, . | Danville, | " | 20 |
| ——,——— and Hulling | H. N. Black, . | Philadelphia, | " | 13 |
| —— Hullers, . | Dyer Green, . | Boston, | Mass. | 6 |
| Saws,—Hanging Circular | David Eldridge, . | Philadelphia, | Penna. | 20 |
| Saw Mills, . | E. G. Dyer, . | Hamilton, | Ohio, | 13 |
| Scalpels, . | A. G. Shaver, . | New Haven, | Conn. | 20 |
| Seed Drills, . | Hiram Moore, . | Brandon, | Wis. | 20 |
| ——— . | Arnton Smith, . | Girard, | Ill. | 27 |
| —— Planters,—Cotton | C. W. McClanahan, | Victoria, | Texas, | 27 |
| Seeding Machines, . | James Morrison, . | Clinton, | Me. | 27 |
| ————— | S. R. Warner, . | London, | Ohio, | 27 |
| Settee or Chair, . | G. L. Buckley, . | W. Barnstable, | Mass. | 20 |
| Sewing Machines,—Loop Catch | L. P. Collins, . | Sacramento, | Cal. | 13 |
| ————— . | Frederick Heyer, . | Richmond, | Va. | 27 |
| ————— . | Rufus Leavitt, . | Melrose, | Mass. | 13 |
| ————— . | R. S. Payne, . | Chicago, | Ill. | 13 |
| Ships Boats,—Attaching | R. S. Stubbs, . | Claremont, | N. H. | 20 |
| —— Sails, . | W. A. Sands, . | Brooklyn, | N. Y. | 20 |
| —— Yards,—Attaching Sails to | John Lewis, . | Elizabeth, | N. J. | 6 |
| Shoes,—India Rubber Tips for | H. B. Goodyear, . | New Haven, | Conn. | 20 |
| Shutter Fastener, . | Jacob Frick, . | Philadelphia, | Penna. | 6 |
| Skate Shoe and Foot Check, | J. B. Gibbs, . | Boston, | Mass. | 13 |

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| Slide Valves, . | R. C. Bristol, . | Chicago, | Ill. | 13 |
| Soap Composition, . | H. N. Willbur, . | Keokuk, | Iowa, | 20 |
| ———————— | M. A. Butler, . | Mariana, | Fa. | 6 |
| Sofa and Bedstead, . | Sewell Pearson, . | Boston, | Mass. | 27 |
| Sounding Apparatuses, | J. B. Van Deusen, | City of | N. Y. | 27 |
| Spelling Boxes, . | D. F. Dunham, . | Brook, | Ind. | 13 |
| Spinal Braces, . | L. B. Wright, . | City of | N. Y. | 6 |
| Spoons,—Burnishing . | H. M. Jacobs, . | Hartford, | Conn. | 27 |
| Stone,—Dressing, . | M. H. Bacon, : | Mystic, | " | 6 |
| Stove Grates, . | L. W. Harwood, . | Troy, | N. Y. | 13 |
| ——————— . | Isaac Smith, . | Albany, | " | 27 |
| Stoves,—Cooking . | DeWitt C. Farrington, | Lowell, | Mass. | 20 |
| ———————— . | Huntley & Caven, | Cincinnati, | Ohio, | 27 |
| ———,—Gas . | Isaac Cressman, . | Philadelphia, | Penna. | 20 |
| Straw Cutters, . | Jacob Schuffelin, Jr., | Tioga, | " | 20 |
| ————————,—Hay and | J. N. Neff, . | Strasburg, | " | 27 |
| Street-sweeping Machines, | Servetus Longley, | Cincinnati, | Ohio, | 13 |
| Swifts, . | C. W. Pearson, . | Charlestown, | Mass. | 13 |
| | | | | |
| Table,—Adjustable | O. C. Dodge, . | Brooklyn, | N. Y. | 20 |
| Tanning,—Apparatus for | J. S. Wheat, . | Wheeling, | Va. | 6 |
| Teeth,—Artificial . | J. W. Moffitt, . | Harrisburg, | Penna. | 20 |
| Threshing Machines,—Spike for | A. B. Colton, . | Athens, | Ga. | 6 |
| Tide Wheels,—Flow of water on | J. G. Ross, . | City of | N. Y. | 6 |
| Trees,—Sustaining . | Wm. H. Livingston, . | " | " | 6 |
| Turning Machines, | George Rugg, . | Potsdam, | " | 13 |
| | | | | |
| Valve Gear of Steam Engines, | J. J. Gwynn, . | Plainfield, | N. J. | 20 |
| Vapor Burners, . | Henry Johnson, . | Washington, | D. C. | 6 |
| | | | | |
| Warming Apparatus, . | L. A. Colbert, . | Baltimore, | Md. | 13 |
| Washing Machines, . | C. F. Chambers, | Chambersburg, | Ind. | 6 |
| ———————— . | Sylvender Ellis, . | N. Britain, | Conn. | 6 |
| ———————— | A. Seamans, . | Bowmansville, | N. Y. | 20 |
| Watches,—Winding . | N. P. Stratton, . | Nashua, | N. H. | 27 |
| Water Carts, . | Henry Austin, | E. Liberty, | Ohio, | 27 |
| Water Closets,—Seats of | G. C. Hinman, . | Portageville, | N. Y. | 6 |
| ———,—Apparatus for Drawing | D. E. Teal, . | Norwich, | " | 27 |
| ——— Elevators and Carriers, | David Johnston, . | Eddyville, | Iowa, | 13 |
| Waterproof Fabrics, | Louis Simonet, . | City of | N. Y. | 6 |
| Wells,—Drawing Water from | Elliot Andrus, . | Geneva, | " | 13 |
| —————————————— | G. D. Colton, . | Galesburg, | Ill. | 13 |
| —————————————— | H. F. Phillips, . | Seneca Falls, | N. Y. | 13 |
| Windlasses,—Capstan | S. P. Patten, . | City of | " | 6 |
| Wire,—Rolling Steel and Iron | John Wright, . | Sheffield, | Engl'd, | 27 |
| Wood,—Bundling Kindling | Wm. L. Williams, | City of | N. Y. | 27 |
| Wrenches, . | Wm. Kearney . | Union, | N. J. | 6 |

EXTENSIONS.

| | | | | |
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| Artificial Legs, . | B. F. Palmer, . | Philadelphia, | Penna. | 6 |
| Telegraph,—Bell . | Judson & Jackson, . | Rochester, | N. Y. | 6 |

ADDITIONAL IMPROVEMENTS.

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| Corn Crushers, . | Amos Glover, . | Powhatan Pt., | Ohio, | 20 |
| Ploughs, . | H. H. Robertson, . | Kingston, | Mo. | 27 |

RE-ISSUES.

| | | | | |
|---|---|---|---|---|
| Air Engines, (2 patents,) | Stephen Wilcox, Jr., | Westerly, | R. I. | 20 |
| Caoutchouc,—Preparing (2 pat's) | Charles Goodyear, . | New Haven, | Conn. | 20 |
| Carpet Sweeper . | H. H. Herrick, . | E. Boston, | Mass. | 20 |
| Glass,—Manufacture of Flint | Horace Trumbull, . | Jersey City, | N. J. | 20 |

| | | | | |
|---|---|---|---|---|
| Harvesters, | S. W. Tyler, | Greenwich, | N. Y. | 13 |
| Hemp Cutters, | Smith & Hardeman, | Springfield, | Ohio, | 23 |
| Lubricating Compound, | J. B. McMunn, | Port Jervis, | N. J. | 20 |
| Photographic Baths, | Bernard Hufnagel, | City of | N. Y. | 13 |
| Sewing Machines, | R. M. Berry, | " | " | 13 |
| Skates, | Wm. Scarlett, | Aurora, | Ill. | 13 |
| Stones,—Raising, &c., | Solomon E. Bolles, | Mattapoisett, | Mass. | 6 |
| Stoves,—Coal | Eddy & Shavor, | Troy, | N. Y. | 13 |
| Valve Cocks,—Action of (2 pat's) | F. H. Bartholomew, | City of | " | 13 |

DESIGNS.

| | | | | |
|---|---|---|---|---|
| Drawer Pull, | Sargent & Bradford, | New Britain, | Conn. | 13 |
| Spoons, Forks, &c.,—Handles of | John Polhamus, | City of | N. Y. | 13 |
| Stove, | Steffe & Sailor, | Philadelphia, | Penna. | 13 |
| —— Doors, | J. D. Marshbank, | Lancaster, | " | 13 |
| Stoves,—Parlor Cooking | N. S. Vedder, | Troy, | N. Y. | 13 |
| Stove Plates,—Cooks | " | " | " | 13 |
| Tea Service, | H. G. Reed, | Taunton, | Mass. | 13 |
| Theodore Parker,—Medallion | T. A. Carew, | Cambridge, | " | 13 |

## FRANKLIN INSTITUTE.

*Proceedings of the Stated Monthly Meeting, January* 17, 1861.

John C. Cresson, President, in the chair.

Isaac B. Garrigues, Recording Secretary.

John F. Frazer, Treasurer.

The minutes of the last meeting were read and approved.

A letter was read from Prof. Dr. Johannes Gistel, of Ratisbonne, Bavaria.

Donations to the Library were received from the Royal Society, London; l'Ecole des Mines, Paris, and la Société Industrielle de Mulhouse, France; the Lower Austrian Mechanics Institute, and the Royal Imperial Geological Association, Vienna, Austria; Prof. Dr. J. Gistel, Ratisbonne, Bavaria; Messrs. Munn & Co., City of New York; Frederick Emmerick, Esq., Washington, D. C.; B. H. Latrobe, Esq., Baltimore, Md.; and Prof. John F. Frazer, Philadelphia.

Donation to the Cabinet from Marine T. W. Chandler, Esq., Engineer of the Don Pedro II. Railroad—specimens of Brazilian Woods.

The Periodicals received in exchange for the Journal of the Institute, were laid on the table.

The Treasurer read his statement of the receipts and payments for the month of December, and his annual statement for 1860.

The annual report of the Committee on Publications, of the state of the Journal for 1860, was read.

The Board of Managers and Standing Committees reported their minutes.

Candidates for membership in the Institute (5) were proposed, and the candidates proposed at the last meeting (6) duly elected.

The Tellers of the Annual Election for Officers, Managers, and Audi-

tors, for the ensuing year, reported the result, when the President declared the following gentlemen duly elected:—

John C. Cresson, President.

John Agnew, Matthias W. Baldwin, } Vice Presidents.

Isaac B. Garrigues, Recording Secretary.

Frederick Fraley, Corresponding Secretary.

John F. Frazer, Treasurer.

MANAGERS.

| | | |
|---|---|---|
| Samuel V. Merrick, | Thomas J. Weygandt, | Washington Jones, |
| Thomas Fletcher, | George Erety, | William Harris, |
| Edwin Greble, | Evans Rogers, | John E. Wootten, |
| Thomas S. Stewart, | Robert Cornelius, | Joseph Hutchinson, |
| Alan Wood, | William Sellers, | Joseph W. Moore, |
| John E. Addicks, | James H. Bryson, | John R. Whitney, |
| Isaac S. Williams, | John M. Gries, | William A. Drown, |
| George W. Conarroe, | James Dougherty, | James S. Mason. |

AUDITORS.

Samuel Mason, James H. Cresson, William Biddle.

At a meeting of the Board of Managers, held January 23d, 1861, the following officers were elected for the ensuing year:

James H. Bryson, Chairman.

Isaac S. Williams, John M. Gries, } Curators.

Mr. C. E. H. Richardson exhibited his patent "Air and Damp-tight Burial Caskets." The shells are composed of ornamental wood; the sides are parallel and the ends semicircular. The top is closed first by a glass plate fitted into a hinged frame, which, when shut down, is covered by a tight lid of wood of the same kind as the shells. The exterior is furnished with the appropriate ornaments. The interior is coated with three applications of the deutoxide of manganese, over which is placed a lining of cork wood, of suitable thickness, prepared with a mixture of collodion and shellac dissolved in benzole. The inside is then lined with satin, or other material usually employed.

The construction is such that air and moisture are excluded, and decomposition of the contained body arrested. They have a handsome appearance, and are recommended by Mr. Barker of Mount Auburn Cemetery, Professor J. Wyman of Harvard University, Professor Jackson, State Assayer of Massachusetts, and others. They have received premiums from the Maryland Institute, and the Mechanics Association of Massachusetts.

Mr. Howson exhibited a Bombshell invented by Wm. Rice, Esq., of this city, and patented in this country and in Europe. The shell is intended to take the place of the *Scharpnell* shell, which consists of a number of spherical balls deposited in a cast iron case, sulphur being poured in to solidify the mass, after which a hole is drilled to make a chamber for the powder. Mr. Rice's shell consists of a number of pieces of cast iron, dovetailed or wedged together, and so

arranged that there is a central compartment for the reception of the powder. The mass of cast iron pieces is formed into a core, around which the shell is cast.

Mr. H. also exhibited a specimen of a Lamp Cap for burning coal oil, the manufacture of J. C. Vankirk & Co., of Frankford, Pa., and pointed out the improvement, which consists of a bolt pressed forward by a spiral spring which takes the place of the ordinary set-screw, and which allows the glass chimney to expand, and yet retains it firmly in its position, thus preventing the breaking of the glass, which often occurs with the ordinary set-screws.

A peculiar construction of Wagon, made by Mr. Smith, of Sullivan County, Pa., was exhibited by Mr. H.; the peculiarity consisting in the entire structure being made of wood. Mr. H. remarked that it seemed almost impossible that a wagon should hold together under such circumstances, but that he had been credibly informed that such was the case. The model attracted much attention.

A specimen of Lamp-stand was also exhibited, which consisted of a simple stem of cast iron, the glass reservoir being attached by means of plaster of paris.

A new Broom, composed of Brazilian Piassaba surrounded by broom-corn, was exhibited by Mr. H. The piassaba plant is very elastic and durable, and has a tendency to penetrate the interstices of the carpet, but owing to its yielding qualities it cannot be made into an efficient broom. By surrounding it with broom-corn, the piassaba is maintained in a comparatively solid mass, and forms with the broom-corn, a most efficient broom.

Mr. H. also exhibited a Gas-burning Stove, the invention of J. L. Mahan, Esq., of this city, and manufactured by Messrs. Stuart & Peterson. The peculiarity of this stove consists in having a plain surface of metal on a level, or thereabouts, with the wire gauze through which the gas passes; the flame, coming in contact with this level surface, heats the air contained in the chamber beneath, and this heated air passes upwards and furnishes that plentiful supply of oxygen which destroys the noxious vapors generated in other gas stoves. The stove was tried in the presence of the meeting, and the President remarked that although some noxious vapors arose from it, it was the best specimen of a gas stove he had seen.

## COMMITTEE ON SCIENCE AND THE ARTS.

### *Report on Robert McWilliams's Improved Axle Box.*

The Committee on Science and the Arts constituted by the Franklin Institute of the State of Pennsylvania, for the promotion of the Mechanic Arts, to whom was referred for examination—"An improved Axle box," invented by Robert McWilliams and assigned to Samuel W. Hoffman,

REPORT:—That they have examined the model of this box, the inventor of which claims that it possesses two peculiarities,—first, that

the lower half of the box is so arranged that it can be detached to be filled with waste and oil in such a manner that upon returning it to its place no oil will be spilled nor the waste disturbed; secondly, that a very simple movable washer is provided at the back of the box which moves up with the journal as the brass wears and keeps the joint always tight and impervious to dust.

The first peculiarity renders the box convenient in oiling and filling, particularly since it permits free access to the journal, one-half of which is entirely exposed.

On the whole, the Committee consider that the arrangement is a simple and ingenious one, and that it is well adapted to fulfil the purpose for which it is intended. As far as the Committee know it is new. The drawings and model accompanying this report will fully explain it.

By order of the Committee,

WM. HAMILTON, *Actuary*.

Philadelphia, March 8th, 1860.

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## *Description by the Inventor.*

Fig. 1 is a side view of the axle box, illustrating the method of connecting and disconnecting the lower half of the same.

Fig. 2, a sectional elevation of the box.

Fig. 3, a transverse section on the line 1, 2, Fig. 2, looking in the direction of the arrow 1.

Fig. 4, a transverse section on the same line, but looking in the direction of the arrow 2; the lower half of the box being removed in this view.

Fig. 5, a sectional plan on the line 3, 4, Fig. 2.

Similar letters refer to similar parts throughout the several views.

A is the upper half, and B the lower detachable half of the axle-box. The upper half, A, has on each side the usual lugs, *a a*, which serve to guide the box during its vertical movement in a hanger of the ordinary construction. C is the brass-bearing, fitting snugly in a recess in the upper half, A, of the box, and maintained in its proper position in front by a lip, *b*, and at the back by a lip, *c*. In front of the upper half, A, of the box, and forming part of the same, are two projections, *d d*, the object of which will be rendered apparent hereafter. In the rear of the box is an opening, *e*, for the admission of the axle, D; the said opening being elongated vertically, in order that the box may be raised to a sufficient height to allow the brass-bearing, C, to be removed and replaced by passing it between the collar, *f*, on the end of the axle and the retaining lip, *b*.

It will be observed, on reference to Fig. 4, that the vertical portion of the upper half, A, of the box, has a flanch, *h*, extending down each side and transversely across the bottom,—thus forming a recess, or socket, for the reception of the end of the oil-box, which forms a part of the lower half, B, of the box. Within the recess formed by the

flanch, *h*, is another recess, for the reception of the leather strip, E, and the metal plate, F,—this recess extending upwards to within a short distance from the top of the box, as seen in Fig. 2.

*Fig. 1*

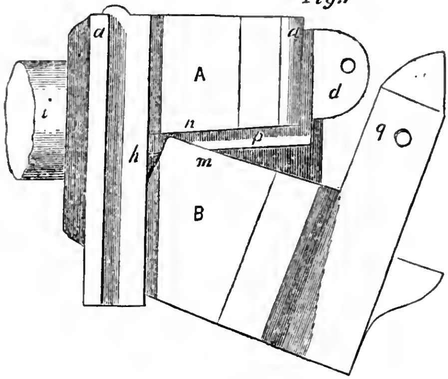



*Fig. 3*

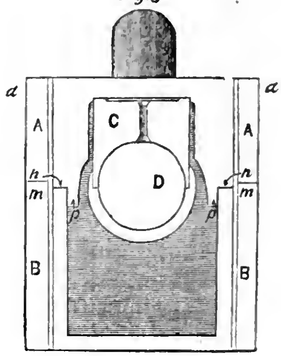



*Fig. 2*

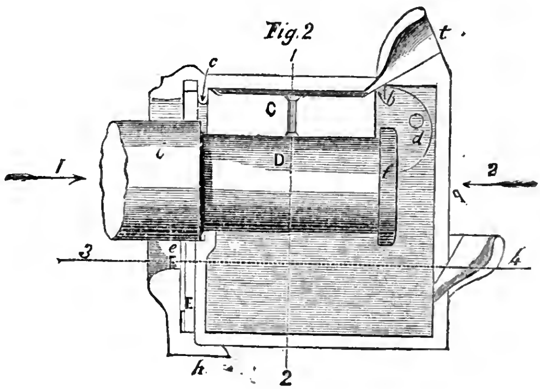



*Fig. 4*

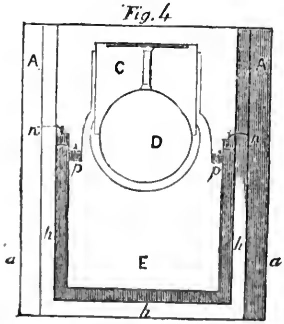
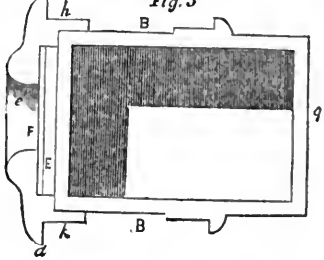



*Fig. 5*




The enlarged portion, *i*, of the axle, D, passes through and fits snug-

ly, but so as to move freely in circular openings, both in the leather strip and iron plate.

It will be seen, on reference to Fig. 2, that the recess for the reception of the leather strip is somewhat longer than the strip itself, thus enabling the latter to rise with the shaft as the brass-bearing wears.

The lower half, B, of the box, the greater portion of which forms the oil-chamber, fits snugly with its end into the socket formed by the flanch, *h*, of the upper half of the box. The upper edges, *m*, of the oil-chamber fit to the inclined shoulders, *n*, on the upper half of the box, a flanch, *p*, projecting from each shoulder a short distance into the inside of the oil-chamber. The vertically projecting portion, *q*, of the lower half of the box, is a continuation of the oil-chamber, and fits snugly over the projections, *d*, of the upper half of the box, a simple bolt passed through this portion, *q*, and through the projections, *d*, being all that is necessary to secure the two halves of the box together. Oil is furnished to the journal through an orifice in a projection, *t*, communicating with a passage in the upper half of the box, through which the oil flows into a channel cut into the top of the brass-bearing, and thence through an opening in the latter to the journal of the axle. The lower oil receiver being on a line parallel with the end, *w*, of the oil-chamber, is also a gauge for the oil.

It will be observed that the point of junction of the edge, *m*, of the lower half, with the edge, *n*, of the upper half of the box, is in a line above the lower line of the journal. In this respect my present improvement is similar to that invented by me, and described in the patent granted to me and Adam J. Frederick, on the 15th day of December, 1857.

In the axle-box described in that patent, however, permanent grooves were formed on each side of the upper half of the box above the line of junction with the lower half, longitudinal projections being formed on the latter to fit into the grooves, so that on adjusting the lower half to the upper half of the box it was necessary to maintain the former in nearly a horizontal position while it was being slided on to the upper half.

There are two serious objections to this mode of securing the two halves together. First, it is necessary that the end of the oil-chamber should be hollowed out sufficiently to escape the outer collar of the journal on sliding the lower half of the box to its place, so that when adjusted the hollow upper edge of the end of the oil-box is so far below the journal that the main body of oil contained in the box is always accessible to the leather packing, and consequently readily finds its way between the latter and the axle; the result being, of course, a great waste of oil.

The second and no less serious objection is, that in sliding the lower half of the box horizontally, or nearly so, so as to fit to the upper half of the box, the outer collar of the axle bears against the cotton packing contained in the oil-chamber, and forces it to the front of the latter, so that the rear part of the journal is free from contact with the said packing, and is, therefore, insufficiently lubricated.

My present improvement has been especially designed to obviate the foregoing objectionable features.

By the peculiar construction of the upper and lower half of the box, the latter, in being adjusted to the frame, is depressed in front, as seen in fig. 1, the end of the oil-chamber resting on the bottom flanch, *h*, of the socket of the upper half of the box. The outer end of the lower half of the box is then gradually raised, and at the same time pressed forward, until the edge, *n*, of the upper half coincides with the edge, *m*, of the lower half, and the projections, *d*, fit into the vertical portion, *q*, of the lower half of the box.

By this arrangement, the end, *w*, of the oil-chamber may be hollowed out to an extent just sufficient to fit snugly to the bearing of the axle, thus excluding the main body of the oil from contact with the leather packing, as seen in fig. 2.

It will also be seen that by this method of adjusting the lower to the upper half of the box, the saturated packing remains undisturbed, and distributes the oil evenly throughout the entire surface of the journal.

The leather strip, E, (which is one piece,) and the plate, F, are retained in their proper position against the end of the box by the end of the oil-chamber, as best observed on reference to fig. 2. As sufficient room is left for the leather strip to rise in its recess as the brass-bearing becomes worn, it is evident that it will adjust itself to the position of the axle, and continue to act as a means of preventing the escape of oil, no matter what may be the extent of the wear of the bearing. The only object of the plate, F, is to prevent the leather strip from bulging outwards into the elongated opening, *e*.

I do not claim broadly making the box in two halves, and so arranging the same that the point of junction shall be above the lower line of the bearing, as this arrangement is covered by the patent granted to me and A. J. Frederick on the 15th day of December, 1857,—the aforesaid S. W. Hoffman being Assignee for the same.

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## METEOROLOGY.

For the Journal of the Franklin Institute.

### *The Meteorology of Philadelphia.* By JAMES A. KIRKPATRICK, A.M.

DECEMBER.—The month of December, 1860, was colder than usual, the temperature being nearly one degree below that of December, 1859, and nearly three degrees below the average temperature of the month for ten years. It was also more equable, the mean daily range being but five degrees, while it is usually about six and a half, and during December, 1859, it was nearly eight and a half degrees.

The Schuylkill river was open to navigation below the dam, during the whole month; it was closed above the dam for two days only.

The warmest day of the month was the 20th, which had a mean temperature of 42·7°. In the afternoon of the same day the thermometer attained its maximum of 50°.

The 15th was the coldest day, the mean temperature being 17·3°. The minimum (13½°) occurred on the same day; making the monthly range of temperature 36½°.

The temperature was below the freezing point on 24 days of the month, though it rose above that point in the course of the afternoon every day except two, namely, the 14th and 15th.

The barometric pressure was greatest on the evening of the 14th, when the mercury stood at 30·418 inches; but the average pressure for the day was greatest on the 29th, the mean for that day being 30·345 inches, while for the 14th it was but 30·300.

The barometric pressure was least on the 20th of the month, falling as low as 29·285 inches during a heavy fog. The average pressure for the day was 29·356 inches.

Rain fell on four and snow on five days. The amount of rain and melted snow (3·301) was the least amount for December since the year 1854, when only 3·185 inches fell.

There were seven days on which the sky was entirely covered with clouds, and only two which were clear or free from clouds at the hours of observation.

TABLE I.—*A Comparison of some of the Meteorological Phenomena of* DECEMBER, 1860, *with those of December*, 1859, *and of the same month for ten years, at Philadelphia.*

| | Dec., 1860. | Dec., 1859. | Dec., 10 years. |
|---|---|---|---|
| Thermometer.—Highest, . . | 50° | 71° | 71° |
| " Lowest, . . | 13·5 | 9 | 4·5 |
| " Daily oscillation, | 12·2 | 14·2 | 12·0 |
| " Mean daily range, | 5·0 | 8·4 | 6·4 |
| " Means at 7 A. M., | 29·32 | 30·66 | 31·65 |
| " " 2 P. M., | 35·65 | 36·48 | 38·91 |
| " " 9 P. M., | 31·82 | 31·87 | 34·44 |
| " " for the month, | 32·26 | 33·00 | 35·00 |
| Barometer.—Highest, . . | 30·418 in. | 30·293 in. | 30·678 in. |
| " Lowest, . . . . | 29·285 | 29·393 | 28·946 |
| " Mean daily range, . | ·196 | ·199 | ·212 |
| " Means at 7 A. M., . | 29·937 | 29·941 | 29·953 |
| " " 2 P. M., . | 29·911 | 29·906 | 29·916 |
| " " 9 P. M., . | 29·958 | 29·930 | 29 939 |
| " " for the month, | 29·936 | 29·926 | 29·936 |
| Force of Vapor.—Means at 7 A. M., | ·132 in. | ·148 in. | ·141 in. |
| " " " 2 P. M., | ·140 | ·171 | ·168 |
| " " " 9 P. M., | ·134 | ·158 | ·153 |
| Relative Humidity.—Means at 7 A. M., | 79 per ct. | 76 per ct. | 77 per ct. |
| " " " 2 P. M., | 66 | 69 | 67 |
| " " " 9 P. M., | 73 | 77 | 75 |
| Rain and melted snow, . . | 3·301 in. | 3·460 in. | 3·876 in. |
| No. of days on which rain or snow fell | 8 | 10 | 11 |
| Prevailing winds, . . . . | N.51°45′W·411 | N.37°45′W·229 | N.53°45′W·281 |

Table II.—*A General Abstract of the Meteorological Observations made at Philadelphia during the year* 1860.

Latitude, 39° 57′ 28″ N. Longitude, 75° 10′ 28″ W. from Greenwich. Height of Barometer fount, fifty feet above mean tide.

| 1860. Months. | Barometer, reduced to 32° F. | | | | | | | | Thermometer. | | | | | | | | | Dew Point at 2 P. M. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Range. | | Means. | | | | | | Range. | | | Means. | | | | | | | |
| | Highest. | Lowest. | Monthly. | Mean daily. | 7 A. M. | 2 P. M. | 9 P. M. | Monthly. | Maximum. | Minimum. | Monthly. | Mean daily. | Mean daily oscillation. | 7 A. M. | 2 P. M. | 9 P. M. | Monthly. | Maximum. | Minimum. | Range. | Mean. |
| | Inch. | Inch. | Inch. | Inch. | Inch. | Inch. | Inch. | Inch. | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° |
| January, | 30·399 | 29·593 | ·806 | ·159 | 29·970 | 29·915 | 29·938 | 29·941 | 58 | 3½ | 54½ | 6·5 | 14·8 | 28·89 | 38·37 | 32·97 | 33·41 | 45·8 | 5·4 | 40·4 | 24·99 |
| February, | 30·358 | 29·099 | 1·259 | ·209 | 29.970 | 29·885 | 29·918 | 29·924 | 70 | 1 | 69 | 8·8 | 17·8 | 27·24 | 38·07 | 31·69 | 32·33 | 54·0 | —3·9 | 57·9 | 24·42 |
| March, | 30·224 | 29·499 | ·725 | ·133 | 29·829 | 29·757 | 29·795 | 29·794 | 73 | 25 | 48 | 5·4 | 18·3 | 38·15 | 52·34 | 43·71 | 44·73 | 58·9 | 10·4 | 48·5 | 28·62 |
| April, | 30·303 | 29·319 | ·984 | ·166 | 29·849 | 29·794 | 29·830 | 29·821 | 81 | 29 | 52 | 7·4 | 18·9 | 43·96 | 56·56 | 47·92 | 49·48 | 59·0 | 13·8 | 45·2 | 35·91 |
| May, | 30·050 | 29·479 | ·571 | ·100 | 29·828 | 29·787 | 29·815 | 29·810 | 90 | 44 | 46 | 5·2 | 17·2 | 59·66 | 71·03 | 61·57 | 64·09 | 63·9 | 37·4 | 26·5 | 53·54 |
| June, | 30·123 | 29·243 | ·880 | ·088 | 29·757 | 29·719 | 29·745 | 29·740 | 93 | 52 | 41 | 4·2 | 18·9 | 67·70 | 78·38 | 69·05 | 71·71 | 71·7 | 38·6 | 33·1 | 56·07 |
| July, | 29·979 | 29·495 | ·481 | ·112 | 29·811 | 29·774 | 29·787 | 29·791 | 95½ | 57 | 38½ | 5·0 | 19·8 | 72·50 | 83·89 | 74·34 | 76·91 | 70·9 | 44·0 | 26·9 | 58·29 |
| August, | 30·026 | 29·632 | ·394 | ·090 | 29·848 | 29·813 | 29·834 | 29·832 | 95 | 55 | 40 | 3·8 | 18·8 | 70·13 | 82·87 | 73·29 | 75·43 | 74·4 | 42·7 | 31·7 | 62·57 |
| September, | 30·313 | 29·597 | ·716 | ·143 | 30·003 | 29·965 | 29·998 | 29·989 | 92 | 42 | 50 | 5·2 | 18·2 | 60·28 | 73·17 | 64·02 | 65·82 | 73·4 | 29·2 | 44·2 | 53·14 |
| October, | 30·275 | 29·312 | ·963 | ·119 | 29·963 | 29·906 | 29·938 | 29·936 | 79 | 36 | 43 | 5·8 | 16·1 | 51·58 | 63·29 | 55·61 | 56·83 | 66·0 | 32·8 | 33·2 | 48·64 |
| November, | 30·305 | 29·248 | 1·057 | ·197 | 29·821 | 29·773 | 29·792 | 29·795 | 80 | 16 | 64 | 5·5 | 14·4 | 43·30 | 50·53 | 45·33 | 46·39 | 62·2 | 12·4 | 49·8 | 35·21 |
| December, | 30·418 | 29·285 | 1·133 | ·196 | 29·937 | 29·911 | 29·958 | 29·936 | 50 | 13½ | 36½ | 5·0 | 12·2 | 29·32 | 35·65 | 31·82 | 32·26 | 38·5 | 5·6 | 32·9 | 24·99 |
| Annual means, | 30·418 | 29·099 | 1·319 | ·143 | 29·882 | 29·833 | 29·862 | 29·859 | 95½ | 1 | 94½ | 5·6 | 17·1 | 49·39 | 60·35 | 52·61 | 54·12 | 71·4 | —3·9 | 78·3 | 42·19 |
| Winter, | 30·399 | 29·099 | 1·300 | ·189 | 29·960 | 29·902 | 29·929 | 29·930 | 71 | 1 | 70 | 7·9 | 15·6 | 28·93 | 37·64 | 32·18 | 32·91 | 61·7 | —3·9 | 65·6 | 25·55 |
| Spring, | 30·303 | 29·319 | ·981 | ·133 | 29·835 | 29·779 | 29·813 | 29·909 | 90 | 25 | 65 | 6·0 | 18·1 | 47·26 | 59·98 | 51·07 | 52·77 | 63·9 | 10·4 | 53·5 | 39·36 |
| Summer, | 30·123 | 29·243 | ·880 | ·097 | 29·805 | 29·769 | 29·789 | 29·788 | 95½ | 52 | 43½ | 4·3 | 19·2 | 70·11 | 81·71 | 72·23 | 74·68 | 74·4 | 38·6 | 35·8 | 58·98 |
| Autumn, | 30·313 | 29·248 | 1·065 | ·153 | 29·929 | 29·881 | 29·909 | 29·906 | 92 | 16 | 76 | 5·5 | 16·2 | 51·72 | 62·33 | 54·99 | 56·35 | 73·4 | 12·4 | 61·0 | 45·66 |
| Means for 9 years, | 30·704 | 28·884 | 1·820 | ·154 | 29·893 | 29·854 | 29·877 | 29·875 | 100½ | —5½ | 106 | 5·6 | 15·0 | 49·69 | 59·98 | 53·19 | 54·29 | 79·7 | —16·5 | 96·2 | 43·74 |

TABLE II (*Continued*).—*A General Abstract of the Meteorological Observations made at Philadelphia during the year* 1860.

| 1860. Months. | Force of Vapor. Maximum. | Force of Vapor. Minimum. | Force of Vapor. Range. | Force of Vapor. Means. 7 A. M. | Force of Vapor. Means. 2 P. M. | Force of Vapor. Means. 9 P. M. | Force of Vapor. Means. Monthly. | Relative Humidity. Maximum. | Relative Humidity. Minimum. | Relative Humidity. Range. | Relative Humidity. Means. 7 A. M. | Relative Humidity. Means. 2 P. M. | Relative Humidity. Means. 9 P. M. | Relative Humidity. Means. Monthly. | Clouds. Sky covered. Means. 7 A. M. | Clouds. Sky covered. Means. 2 P. M. | Clouds. Sky covered. Means. 9 P. M. | Clouds. Sky covered. Means. Mon'ly | Rain and melt'd snow. Amount. | Rain and melt'd snow. No. of days it fell. | Winds. Monthly resultant. | Winds. No. of times in 1000. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Inch. | Inch. | Inch. | Inch. | Inch. | Inch. | Inch. | Pr ct. | Pr ct. | P ct. | Per ct. | Per ct. | Per ct. | Per ct. | | | | | Inch. | | Direction. | |
| January, | ·308 | ·040 | ·268 | ·136 | ·144 | ·143 | ·141 | 95 | 24 | 71 | 79·9 | 60·8 | 73·4 | 71·4 | ·66 | ·64 | ·51 | ·60 | 3·351 | 7 | N 89° 9′ W | 402 |
| February, | ·434 | ·024 | ·410 | ·124 | ·154 | ·150 | ·143 | 100 | 35 | 65 | 74·1 | 58·7 | 71·9 | 68·2 | ·53 | ·49 | ·44 | ·49 | 2·724 | 7 | N 61 52 W | 298 |
| March, | ·497 | ·064 | ·433 | ·171 | ·175 | ·182 | ·176 | 97 | 16 | 81 | 71·4 | 44·3 | 61·5 | 59·1 | ·61 | ·55 | ·40 | ·52 | 1 323 | 8 | N 79 17 W | 224 |
| April, | ·500 | ·081 | ·419 | ·210 | ·234 | ·230 | ·225 | 100 | 21 | 79 | 70·1 | 50·3 | 67·1 | 62·5 | ·52 | ·59 | ·52 | ·54 | 3·646 | 15 | N 88 36 W | 250 |
| May, | ·638 | ·224 | ·414 | ·395 | ·421 | ·420 | ·412 | 94 | 28 | 66 | 76·2 | 56·7 | 75 6 | 69·5 | ·75 | ·67 | ·65 | ·69 | 3·589 | 19 | N 59 2 E | 70 |
| June, | ·804 | ·211 | ·593 | ·467 | ·464 | ·480 | ·470 | 94 | 26 | 68 | 68·1 | 48·4 | 66·7 | 61·1 | ·59 | ·57 | ·33 | ·50 | 3·706 | 10 | N 67 23 W | 236 |
| July, | ·783 | ·288 | ·495 | ·539 | ·505 | ·559 | ·534 | 90 | 29 | 61 | 66·5 | 43·4 | 65·3 | 58·4 | ·52 | ·59 | ·40 | ·50 | 0·851 | 10 | S 70 1 W | 135 |
| August, | ·850 | ·275 | ·575 | ·580 | ·584 | ·603 | ·589 | 94 | 27 | 67 | 77·5 | 52·1 | 73·0 | 67·5 | ·53 | ·57 | ·48 | ·53 | 9·260 | 13 | N 80 54 W | 150 |
| September, | ·822 | ·161 | ·661 | ·425 | ·437 | ·455 | ·439 | 93 | 35 | 58 | 77·1 | 50 4 | 72·1 | 66·5 | ·62 | ·50 | ·35 | ·49 | 2·907 | 7 | S 74 26 W | 397 |
| October, | ·639 | ·172 | ·467 | ·321 | ·363 | ·354 | ·346 | 95 | 41 | 54 | 80·4 | 60·6 | 77·4 | 72·8 | ·64 | ·62 | ·50 | ·59 | 4·685 | 13 | S 75 58 W | 69 |
| November, | ·568 | ·058 | ·510 | ·234 | ·228 | ·236 | .233 | 93 | 35 | 58 | 76·2 | 57·0 | 71·4 | 68·2 | ·64 | ·61 | ·48 | ·58 | 6 057 | 12 | N 81 25 W | 333 |
| December, | ·275 | ·056 | ·219 | ·132 | ·140 | ·134 | ·135 | 92 | 38 | 54 | 78·9 | 65·8 | 72·7 | 72·5 | ·64 | ·69 | ·48 | ·60 | 3·301 | 8 | N 51 45 W | 411 |
| Annual means, | ·850 | ·024 | ·826 | ·311 | ·321 | ·329 | ·320 | 100 | 16 | 84 | 74·7 | 54·0 | 70·7 | 66 5 | ·60 | ·59 | ·46 | ·55 | 45·400 | 129 | N 79 43 W | 219 |
| Winter,[1] | ·551 | ·024 | ·527 | ·136 | ·156 | ·150 | ·147 | 100 | 24 | 76 | 76·8 | 63·0 | 74 2 | 71·3 | ·63 | ·63 | ·48 | ·58 | 9·535 | 24 | N 67 50 W | 289 |
| Spring, | ·638 | ·064 | ·574 | ·259 | ·277 | ·277 | ·271 | 100 | 16 | 84 | 72·6 | 50·4 | 68·1 | 63·7 | ·63 | ·60 | ·52 | ·58 | 8 558 | 42 | N 76 26 W | 119 |
| Summer, | ·850 | ·211 | ·639 | ·529 | ·518 | ·547 | ·531 | 94 | 26 | 68 | 70·7 | 48·0 | 68·3 | 62·3 | ·55 | ·58 | ·40 | ·51 | 13 817 | 33 | N 82 27 W | 165 |
| Autumn, | ·822 | ·058 | ·764 | ·327 | ·343 | ·348 | ·339 | 95 | 35 | 60 | 77·9 | 56·0 | 73·6 | 69·2 | ·63 | ·58 | ·44 | ·55 | 13·649 | 32 | S 84 34 W | 254 |
| Means for 9 years, | 1·059 | ·013 | 1·046 | ·327 | ·345 | ·347 | ·340 | 100 | 13 | 87 | 76·4 | 57·9 | 72·5 | 68·9 | ·59 | ·59 | ·44 | ·54 | 44·692 | 126 | N 74° 51′ W | 215 |

The Year 1860.—The temperature of the year was about two-tenths of a degree below the average temperature for nine years. The coldest day was the 2d of February, of which the mean temperature was 9·2°, and the minimum (1°) was reached on the same day.

The warmest day was the 20th of July, of which the mean temperature was 87·7°, and the thermometer marked the highest degree (95½°) on the same day.

The greatest barometric pressure was 30·418 inches on the 14th of December, and the least, 29·099 inches, on the 18th of February.

The Delaware river was not closed with ice during the whole year; it has not been closed to navigation since the beginning of March, 1858. The Schuylkill was closed for about two weeks in the beginning of January, 1860.

Table II. contains a general abstract of the observations made during the year; the barometric observations being corrected for temperature, but not for altitude; the barometer fount being fifty feet above mean tide in the Delaware river.

Table III. contains a comparison, in the usual form, of the year 1860 with 1859, and with the average results for nine years.

Table III.—*A Comparison of some of the Meteorological Phenomena of the year* 1860, *with those of* 1859, *and of the last nine years, at Philadelphia.*

| | 1860. | 1859. | Nine years. |
|---|---|---|---|
| Thermometer.—Highest, | *a* 95·5° | *e* 97° | *i* 100.5° |
| " Lowest, | *b* 1·0 | *f* —2 | *j* —5·5 |
| " Daily oscillation, | 17·12 | 17·20 | 14·99 |
| " Mean daily range, | 5·65 | 6·00 | 5·62 |
| " Means at 7 A. M., | 49·39 | 49·93 | 49·69 |
| " " 2 P. M., | 60·35 | 60·53 | 59·98 |
| " " 9 P. M., | 52·61 | 53·00 | 53·19 |
| " " for the year, | 54·12 | 54·49 | 54·29 |
| Barometer.—Highest, | *c* 30·418 in. | *g* 30·475 in. | *k* 30·704 in. |
| " Lowest, | *d* 29·099 | *h* 28·890 | *l* 28·884 |
| " Mean daily range, | ·143 | ·158 | ·154 |
| " Means at 7 A. M., | 29·882 | 29·881 | 29·893 |
| " " 2 P. M., | 29·833 | 29·840 | 29·854 |
| " " 9 P. M., | 29·862 | 29·867 | 29·877 |
| " " for the year, | 29·859 | 29 863 | 29·875 |
| Force of Vapor.—Means at 7 A. M., | ·311 in | ·313 in. | ·327 in. |
| " " " 2 P. M., | ·321 | ·331 | ·345 |
| " " " 9 P. M., | ·329 | ·332 | ·347 |
| Relative Humidity.—Means at 7 A. M., | 75 per ct. | 75 per ct. | 76 per ct. |
| " " " 2 P. M., | 54 | 56 | 58 |
| " " " 9 P. M., | 71 | 71 | 73 |
| Rain and melted snow, | 45·400 in. | 54·752 in. | 44.692 in. |
| No. of days on which rain or snow fell, | 129 days. | 127 days. | 126 days. |
| Prevailing winds, | N.79°43′W·219 | N.79°31′W·255 | N.74°51′W·215 |

*a* July 20. *b* February 2. *c* December 14. *d* February 18. *e* July 13 and August 4. *f* January 10. *g* January 24. *h* April 23. *i* 1854, July 21. *j* 1857, January 23. *k* 1853, January 28. *l* 1852, April 21.

*Abstract of Meteorological Observations for November,* 1860; *made in Philadelphia, Franklin, and Somerset Counties, Pennsylvania, for the Committee on Meteorology of the Franklin Institute.*

| 1860. | PHILADELPHIA.—Lat. 39° 57′ 28″ N. Long. 75° 10′ 28″ W. Height above the sea 50 feet. Prof. J. A. KIRKPATRICK, Observer. | | | | | | | | | CHAMBERSBURG, Franklin Co. Lat. 39° 58′ N. Long. 77° 45′ W. Height 618 ft. WM. HEYSER, Jr., Observer. | | | | | | | SOMERSET, Somerset Co. Lat. 40° N. Long. 79° 3′ W. Height 2195 feet. GEO. MOWRY, Observer. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Barometer. | | Thermometer. | | | Force of vapor. | Relative humidity. | Rain and snow. | Prevail'g winds. | Barom | Thermom. | | Force of vapor. | Relative humidity. | Rain and snow. | Prevail'g winds. | Barom | Thermom. | | Force of vapor. | Relative humidity. | Rain and snow. | Prevail'g winds. |
| Nov. | Mean. | Mean daily range | Mean. | Daily oscil-lation. | Mean daily range. | 2 P.M. | 2 P.M. | | | Mean. | Mean. | Mean daily range. | 2 P.M. | 2 P.M. | | | Mean. | Mean. | Mean daily range. | 2 P.M. | 2 P.M | | |
| | Inch. | Inch. | ° | ° | ° | Inch. | Per ct. | Inches. | Direc. | Inch. | ° | ° | Inch. | Per ct | Inch. | Direc. | Inch. | ° | ° | Inch. | Per ct. | Inch. | Direc. |
| 1 | 30·069 | ·056 | 69·0 | 18 | 1·7 | ·560 | 60 | 0·016 | S E. | 29·404 | 67·7 | 0·7 | ·658 | 90 | | (var.) | 27·761 | 62·0 | 1·0 | ·475 | 69 | | E S E. |
| 2 | 30·067 | ·018 | 67·2 | 14 | 2·2 | ·524 | 65 | 0·025 | E S E. | 29·348 | 68·0 | 0·3 | ·572 | 75 | 1·860 | E. | 27·698 | 60·7 | 2·0 | ·490 | 81 | 2·192 | E. |
| 3 | 29·628 | ·439 | 62·5 | 7 | 5·0 | ·507 | 91 | 2·998 | N E. | 29·057 | 62·7 | 8·7 | ·452 | 94 | | (var.) | 27·538 | 51·3 | 8·7 | ·295 | 73 | | W. |
| 4 | 29·812 | ·245 | 51·8 | 15 | 10·7 | ·187 | 41 | | W. | 29·211 | 47·3 | 12·0 | ·183 | 49 | | W. | 27·614 | 40·3 | 11·0 | ·185 | 58 | | W. |
| 5 | 29·825 | ·103 | 54·0 | 22 | 7·2 | ·224 | 40 | | S W. | 29·142 | 50·7 | 7·3 | ·269 | 54 | | (var.) | 27·545 | 46·7 | 6·3 | ·242 | 52 | | (var.) |
| ☾ 6 | 29·796 | ·088 | 47·2 | 13 | 7·8 | ·142 | 35 | | W N W | 29·208 | 48·3 | 2·7 | ·020 | 41 | | W. | 27·611 | 35·3 | 11·3 | ·103 | 45 | | W. |
| 7 | 29·991 | ·195 | 43·3 | 16 | 3·8 | ·135 | 37 | | W N W | 29·387 | 41·3 | 7·3 | ·121 | 36 | | W. | 27·749 | 35·0 | 2·3 | ·125 | 49 | | W N W. |
| 8 | 30·023 | ·058 | 43·8 | 16 | 1·8 | ·188 | 51 | | N W. | 29·416 | 43·3 | 2·0 | ·189 | 56 | | S E. | 27·746 | 40·7 | 9·7 | ·220 | 59 | | N. |
| 9 | 29·866 | ·157 | 45·5 | 9 | 3·0 | ·203 | 59 | 0·998 | (var.) | 29·138 | 45·7 | 4·3 | ·249 | 77 | 1·215 | S E. | 27·489 | 42·7 | 6·7 | ·283 | 85 | 1·181 | E. |
| 10 | 29·285 | ·581 | 49·0 | 11 | 4·5 | ·199 | 62 | 0·009 | S S W. | 28·751 | 43·7 | 3·3 | ·177 | 66 | | W. | 27·219 | 34·3 | 8·3 | ·162 | 84 | 0·246 | W. |
| 11 | 29·517 | ·231 | 46·2 | 6 | 3·5 | ·206 | 65 | 0·003 | N W. | 28·969 | 48·0 | 4·3 | ·209 | 58 | | W. | 27·430 | 37·3 | 3·7 | ·175 | 69 | | W. |
| ● 12 | 29·581 | ·065 | 47·3 | 14 | 2·5 | ·255 | 66 | | N W. | 29·003 | 47·3 | 3·3 | ·181 | 43 | | W. | 27·441 | 39·3 | 4·7 | ·212 | 63 | | (var.) |
| 13 | 29·756 | ·175 | 47·3 | 9 | 0·0 | ·229 | 59 | | N W. | 29·218 | 48·7 | 1·3 | ·192 | 44 | | W. | 27·683 | 41·0 | 2·3 | ·212 | 63 | | N W. |
| 14 | 29·910 | ·154 | 49·3 | 17 | 4·7 | ·212 | 46 | | N W. | 29·363 | 46·3 | 4·3 | ·229 | 48 | | W. | 27·785 | 39·3 | 3·0 | ·185 | 51 | | W. |
| 15 | 29·964 | ·054 | 49·8 | 13 | 2·5 | ·240 | 55 | | N W. | 29·399 | 47·7 | 3·3 | ·179 | 40 | | W. | 27·798 | 38·3 | 3·7 | ·194 | 48 | | ? |
| 16 | 30·004 | ·046 | 49·3 | 16 | 1·2 | ·240 | 55 | | N W. | 29·412 | 45·0 | 5·3 | ·194 | 48 | | (var.) | 27·772 | 41·3 | 3·0 | ·268 | 62 | | S W. |
| 17 | 29·781 | ·222 | 51·3 | 15 | 2·0 | ·292 | 65 | | N W. | 29·135 | 47·7 | 4·0 | ·296 | 79 | 0·365 | (var.) | 27·507 | 45·7 | 5·0 | ·281 | 63 | | S. |
| 18 | 29·404 | ·378 | 50·7 | 9 | 3·3 | ·266 | 61 | 0·281 | (var.) | 28·763 | 46·3 | 3·3 | ·234 | 65 | | (var.) | 27·212 | 38·3 | 7·3 | ·203 | 82 | 0·021 | W. |
| 19 | 29·448 | ·045 | 50·5 | 14½ | 3·2 | ·252 | 56 | | S W. | 28·734 | 47·3 | 1·0 | ·258 | 72 | | W. | 27·158 | 39·7 | 2·0 | ·208 | 75 | 0·265 | (var.) |
| ☽ 20 | 29·615 | ·167 | 43·0 | 13 | 7·5 | ·139 | 42 | 0·007 | W. | 29·064 | 42·0 | 5·3 | ·121 | 43 | | W. | 27·410 | 30·7 | 9·0 | ·128 | 64 | | W. |
| 21 | 29·774 | ·159 | 38·0 | 12 | 5·0 | ·110 | 41 | | W S W | 29·150 | 36·3 | 5·7 | ·131 | 55 | | W. | 27·479 | 28·3 | 2·3 | ·175 | 94 | 0·034 | (var.) |
| 22 | 29·997 | ·223 | 37·0 | 15 | 1·0 | ·131 | 49 | | (var.) | 29·364 | 36·3 | 4·0 | ·105 | 41 | | S W. | 27·657 | 30·3 | 5·3 | ·129 | 61 | 0·236 | (var.) |
| 23 | 29·739 | ·258 | 47·7 | 21 | 10·7 | ·297 | 92 | 0·654 | S E. | 29·025 | 38·0 | 3·0 | ·194 | 82 | 0·316 | N E. | 27·335 | 38·3 | 8·0 | ·214 | 69 | 0·773 | S. |
| 24 | 29·667 | ·281 | 27·2 | 35 | 20·5 | ·087 | 58 | | W. | 29·015 | 20·3 | 17·7 | ·076 | 70 | | W. | 27·394 | 11·0 | 27·3 | ·056 | 65 | | W. |
| 25 | 30·092 | ·424 | 23·3 | 13 | 7·2 | ·076 | 52 | | W S W | 29·452 | 21·3 | 6·3 | ·061 | 41 | 0·315 | W. | 27·749 | 12·7 | 4·3 | ·081 | 77 | | W. |
| 26 | 30·234 | ·144 | 33·7 | 18¼ | 10·3 | ·087 | 37 | 0·774 | (var.) | 29·526 | 31·0 | 9·7 | ·114 | 61 | | W. | 27·795 | 26·7 | 14·0 | ·101 | 55 | 0·770 | S. |
| 27 | 29·901 | ·333 | 49·3 | 13 | 15·7 | ·347 | 93 | 0·220 | (var.) | 29·260 | 40·0 | 9·0 | ·244 | 91 | | N E. | 27·638 | 42·0 | 15·3 | ·298 | 92 | 0·123 | W. |
| ○ 28 | 29·936 | ·071 | 39·0 | 14 | 10·3 | ·145 | 56 | | N W. | 29·300 | 36·7 | 4·3 | ·113 | 42 | | W. | 27·675 | 30·7 | 11·3 | ·152 | 64 | | N W. |
| 29 | 29·779 | ·157 | 37·5 | 15 | 3·8 | ·122 | 43 | | N W. | 29·164 | 37·3 | 5·7 | ·186 | 67 | | (var.) | 27·471 | 32·3 | 7·7 | ·177 | 66 | | S W. |
| 30 | 29·408 | ·372 | 40·8 | 9 | 3·3 | ·233 | 79 | 0·072 | S S W. | 28·979 | 40·7 | 6·7 | ·125 | 40 | 0·110 | (var.) | 27·105 | 35·3 | 6·3 | ·203 | 82 | 0·253 | W S W |
| Means | 29·795 | ·197 | 46·4 | 14½ | 5·5 | ·228 | 57 | 6·057 | N 81½° W | 29·202 | 44·1 | 5·2 | ·214 | 59 | 4·181 | S 64½° W | 27·549 | 37·6 | 7·1 | ·280 | 67 | 6·094 | S 68¾° W |

*Abstract of Meteorological Observations for November, 1860; made in Adams, Dauphin, Northumberland, Centre, and Erie Counties, Pennsylvania, for the Committee on Meteorology of the Franklin Institute.*

| 1860. Nov. | Gettysburg, Adams Co. Lat. 39° 49′ N. Long. 77° 18′ W. Ht. 624 ft. Prof. M. Jacobs, Obs. Barom. Mean. | Thermom. Mean. | Thermom. Mean daily range. | Rain and snow. | Prevail'g winds. |
|---|---|---|---|---|---|
| | Inch. | ° | ° | Inch. | Direc. |
| 1 | 29·577 | 68·7 | 4·0 | 0·333 | S S E. |
| 2 | 29·535 | 67·3 | 2·0 | 0·012 | E S E. |
| 3 | 29·286 | 60·3 | 7·0 | 0·490 | (var.) |
| 4 | 29·407 | 44·3 | 16·0 | | (var.) |
| 5 | 29·336 | 47·3 | 6·3 | | S W. |
| ☾ 6 | 29·386 | 38·7 | 8·7 | | (var.) |
| 7 | 29·561 | 38·7 | 2·0 | | N W. |
| 8 | 29 638 | 43·7 | 8·0 | | S W. |
| 0 | 29·364 | 46·3 | 5·7 | | N N E. |
| 10 | 28·948 | 41·3 | 5·0 | } 1·275 | W. |
| 11 | 29·119 | 45·3 | 4 0 | | N W. |
| ● 12 | 29·200 | 46·0 | 3·3 | | N W. |
| 13 | 29·421 | 48·0 | 2·0 | | N W. |
| 14 | 29·556 | 45·7 | 4·3 | | N W. |
| 15 | 29·588 | 44·3 | 1·3 | | W. |
| 16 | 29·615 | 43·7 | 2·7 | | (var ) |
| 17 | 29·285 | 45·7 | 6·0 | 0·195 | W. |
| 18 | 28·093 | 40·0 | 3·0 | | (var.) |
| 19 | 28·970 | 45·7 | 1·7 | | S W. |
| ☽ 20 | 29 329 | 38·0 | 8·3 | | N W. |
| 21 | 29·365 | 34·0 | 4·0 | | (var.) |
| 22 | 29·582 | 32·7 | 4·0 | | S W. |
| 23 | 29·274 | 35·3 | 4·7 | 0·850 | S W. |
| 24 | 29·202 | 17·3 | 18·0 | | N W. |
| 25 | 29·703 | 18·3 | 7·0 | | (var.) |
| 26 | 29·791 | 29·3 | 7·7 | | W. |
| 27 | 29·529 | 40·0 | 14 0 | 0·850 | S W. |
| ○ 28 | 20·529 | 34·3 | 5·7 | | N. |
| 29 | 29·323 | 31·7 | 6·7 | | (var.) |
| 80 | 28·893 | 37·3 | 5·7 | | S W. |
| Means | 29·380 | 41·5 | 6·0 | 4·005 | West. |

| 1860. Nov. | Harrisburg, Dauphin Co. 40°16′, N. 76°50′, W. Ht., 300 ft. John Heisely, M.D., Obs. Barom. Mean. | Thermom. Mean. | Thermom. Mean daily range. | Rain and snow. | Prevail'g winds. |
|---|---|---|---|---|---|
| | Inch. | ° | ° | Inch. | Direc. |
| 1 | 29·925 | 70·7 | 2·7 | | S E. |
| 2 | 29·902 | 68·0 | 2·7 | } 0·672 | E. |
| 3 | 29·562 | 63·3 | 4·7 | | N E. |
| 4 | 29 704 | 51·0 | 12·3 | | W. |
| 5 | 29 656 | 52·3 | 5·3 | | S W. |
| ☾ 6 | 29·691 | 46·0 | 7·0 | | N W. |
| 7 | 29·871 | 44·7 | 1·3 | | N W. |
| 8 | 29·933 | 44·7 | 2·0 | | N. |
| 0 | 29·692 | 46·7 | 2·7 | | N. |
| 10 | 29·209 | 46·3 | 1·0 | } 1·418 | W. |
| 11 | 29·410 | 50·0 | 3·7 | | N W. |
| ● 12 | 29·484 | 50·0 | 2·7 | | N. |
| 13 | 29·688 | 52·0 | 2·0 | | N. |
| 14 | 29·852 | 51·3 | 0·7 | | N. |
| 15 | 29·885 | 49·3 | 2·0 | | N. |
| 16 | 29·913 | 49·3 | 1·3 | | N. |
| 17 | 29·628 | 51·3 | 2·7 | } 0·128 | N. |
| 18 | 29·268 | 50·7 | 4·7 | | W. |
| 19 | | | | | S W. |
| ☽ 20 | 29·499 | 42·0 | | | W. |
| 21 | 29·641 | 39·7 | 2·3 | | W· |
| 22 | 29·883 | 38·7 | 1·7 | | (var.) |
| 23 | 29·573 | 40·0 | 2·7 | } 0·642 | S E. |
| 24 | 29·525 | 24·3 | 15·7 | | W. |
| 25 | 29·977 | 23·3 | 8·3 | | W. |
| 26 | 30·121 | 30·7 | 7·3 | | S E. |
| 27 | 29·705 | 41·7 | 11·0 | 0·583 | S E. |
| ○ 28 | 29·814 | 37·7 | 4·0 | | N. |
| 29 | | | | | N. |
| 80 | 29·196 | 39·0 | | | (var.) |
| Means | 29·690 | 46·2 | 4·4 | 3·443 | N 51° W |

| 1860. Nov. | Shamokin, Northumberland Co. 40° 45′ N. 76° 30′ W. Height, 700 ft. P. Friel, Obs. Thermom. Mean. | Thermom. Mean daily range. | Rain and snow. | Prevail'g winds. |
|---|---|---|---|---|
| | ° | ° | Inch. | Direc. |
| 1 | 67·3 | 2·3 | 0·151 | E. |
| 2 | 65·3 | 2·0 | 0·100 | E. |
| 3 | 61·0 | 4·3 | 0·891 | (var.) |
| 4 | 61·0 | 0·0 | | E. |
| 5 | 51·0 | 10·7 | | (var.) |
| ☾ 6 | 42·0 | 10·3 | 0·050 | (var.) |
| 7 | 40·0 | 3·3 | | W. |
| 8 | 38·3 | 3·7 | | W. |
| 0 | 43·3 | 5·0 | } 1·638 | S E. |
| 10 | 44·0 | 2·7 | | W. |
| 11 | 42·7 | 4·7 | 0·151 | W. |
| ● 12 | 45·7 | 3·0 | | W. |
| 13 | 45·3 | 2·3 | | W. |
| 14 | 43·3 | 2·0 | | W. |
| 15 | 38·3 | 5·7 | | W. |
| 16 | 43·7 | 5·3 | | W. |
| 17 | 45·0 | 2·7 | | W. |
| 18 | 47·3 | 6·3 | | (var.) |
| 19 | 45·7 | 3·0 | 0·130 | (var.) |
| ☽ 20 | 41·0 | 8·0 | | W. |
| 21 | 34·0 | 7·0 | | E. |
| 22 | 34·0 | 6·0 | 0·070 | W. |
| 23 | 37·3 | 6·0 | 0·603 | E. |
| 24 | 19·3 | 17·7 | | W. |
| 25 | 18·3 | 7·0 | | W. |
| 26 | 24·0 | 5·7 | | (var.) |
| 27 | 43·3 | 19·3 | 0 806 | E. |
| ○ 28 | 35·7 | 7·7 | | W. |
| 29 | 31·0 | 11·3 | | W. |
| 80 | 40·3 | 9·3 | | W. |
| Means | 42·3 | 6·1 | 4·590 | S 83° W |

| 1860. Nov. | Fleming, Centre Co. 40° 55′ N. 77° 53′ W. Ht., 780 feet. S. Brugger, Obs. Thermom. Mean. | Thermom. Mean daily range. | Rain and snow. | Prevail'g winds. |
|---|---|---|---|---|
| | ° | ° | Inch. | Direc. |
| 1 | 67·0 | 2·3 | 0·200 | (var.) |
| 2 | 65·7 | 2·7 | 0 100 | S E. |
| 3 | 57·0 | 8·7 | 1·300 | (var.) |
| 4 | 40·7 | 16·3 | | N W. |
| 5 | 47·0 | 12·3 | | W. |
| ☾ 6 | 37·7 | 11·3 | | N W. |
| 7 | 36·0 | 2·3 | | N W. |
| 8 | 38·0 | 7·3 | | W. |
| 0 | 41·7 | 6·3 | 0·820 | (var.) |
| 10 | 41·7 | 1·3 | 0·600 | N W. |
| 11 | 46·0 | 4·3 | 0·105 | N W. |
| ● 12 | 44·3 | 5·7 | | W. |
| 13 | 46·7 | 2·3 | | (var.) |
| 14 | 43·0 | 4·3 | | (var.) |
| 15 | 42 0 | 1·0 | | (var.) |
| 16 | 45·0 | 3·0 | | W. |
| 17 | 47·0 | 5·3 | | S E. |
| 18 | 43·7 | 7·3 | | (var.) |
| 19 | 41·0 | 4·7 | | W. |
| ☽ 20 | 35·3 | 5·7 | | N W. |
| 21 | 34·0 | 1·3 | | N W. |
| 22 | 33·7 | 3·0 | 0·305 | W. |
| 23 | 36·7 | 3·0 | 0·080 | S W. |
| 24 | 14·0 | 22·7 | | N W. |
| 25 | 13·7 | 4·3 | | N W. |
| 26 | 26 7 | 13·0 | } 0·875 | W. |
| 27 | 42·3 | 15·7 | | W. |
| ○ 28 | 29·7 | 12·7 | | (var.) |
| 29 | 29·0 | 12·7 | | W. |
| 80 | 40·3 | 11·3 | | W. |
| Means | 40·4 | 7·1 | 4·385 | N 81° W |

| 1860. Nov. | Erie, Erie Co.—Lat. 42° 8′ N. Long. 80° 12′ W. Height (about 61) feet. Benjamin Grant, Obs. Barom. Mean | Thermom. Mean. | Thermom. Mean daily range. | Force of Vapor. 2 P. M. | Relative humidity. 2 P. M. | Rain and snow. | Prevail'g winds. |
|---|---|---|---|---|---|---|---|
| | Inch. | ° | ° | Inch. | Per ct. | Inch. | Direc. |
| 1 | 29·362 | 69·0 | 2·3 | ·479 | 55 | | S W. |
| 2 | 29·309 | 61·7 | 11·3 | ·394 | 76 | } 1·800 | (var.) |
| 3 | 29·217 | 58·3 | 6·0 | ·281 | 47 | | S. |
| 4 | 29·190 | 49·7 | 8·7 | ·105 | 25 | | S W. |
| 5 | 29·122 | 49·3 | 5·0 | ·159 | 44 | } 0·050 | W. |
| ☾ 6 | 29·291 | 43·3 | 6·0 | ·153 | 57 | | W. |
| 7 | 29·476 | 41·7 | 4 3 | ·166 | 53 | | W. |
| 8 | 29·479 | 39·7 | 4 0 | ·180 | 60 | | (var.) |
| 0 | 29·115 | 46·7 | 6·3 | ·261 | 84 | } 1·700 | E. |
| 10 | 28·033 | 43·3 | 3·3 | ·250 | 84 | | N. |
| 11 | 29·121 | 48·3 | 5·0 | ·267 | 66 | 0·300 | N W. |
| ● 12 | 29·158 | 44·7 | 3·7 | ·245 | 70 | | N. |
| 13 | 29·392 | 46·0 | 1·3 | ·243 | 65 | | N. |
| 14 | | | | ·320 | 79 | | N. |
| 15 | | | | | | | |
| 16 | | | | | | | |
| 17 | 29·135 | 52·0 | | ·252 | 52 | | S. |
| 18 | 28·816 | 44·0 | 8·0 | ·166 | 53 | 0·360 | N. |
| 19 | 28·717 | 42·0 | 2·7 | ·062 | 21 | | W. |
| ☽ 20 | 29·372 | 39 3 | 3·7 | ·153 | 57 | | W. |
| 21 | 29·201 | 34·7 | 4·3 | ·141 | 69 | | W. |
| 22 | 29·335 | 38·0 | 4·0 | ·110 | 41 | } 0·440 | S W. |
| 23 | 29·066 | 39·0 | 3·0 | ·131 | 49 | | S. |
| 24 | 29·044 | 11·7 | 27·3 | ·075 | 100 | | W. |
| 25 | 29·451 | 13·7 | 6·7 | ·055 | 53 | | S W. |
| 26 | 29·385 | 30·7 | 13·7 | ·154 | 79 | } 0·850 | S. |
| 27 | 29·301 | 42·0 | 11·3 | ·126 | 44 | | W. |
| ○ 28 | 29·390 | 35·7 | 4·0 | ·081 | 31 | | W. |
| 29 | 29·076 | 41·3 | 6·7 | ·148 | 51 | | S W. |
| 80 | 28·740 | 38·7 | 6·7 | ·202 | 82 | 0·170 | (var.) |
| Means | 29·192 | 42·4 | 6·5 | ·191 | 50 | 5·670 | S 80° W |

JOURNAL

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# THE FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

**MARCH, 1861.**

## CIVIL ENGINEERING.

For the Journal of the Franklin Institute.

*Repairs and Renewal of the Roche-Bernard Suspension Bridge.* From a description given by M. Noyon, Engineer. Translated by J. Bennett.

Part Second.

(Continued from page 108.)

*Rebuilding of the Platform of the Bridge.*—After the fall of the platform, measures were immediately taken to provide for the travel across the Vilaine, in establishing a ferry upon the site formerly used by a barge, previous to the construction of the bridge. Nearly all the wood-work of the platform was recovered; but, excepting the beams, the principal pieces of carpentry were all injured and unfit for use; and as the shortness of the beams had contributed to the fall of the platform, it was determined to use new material.

The design of M. Lacroix, Eng., was approved by the administration, who ordered the work to be vigorously executed. Unfortunately, the proper wood could not be found in the yards of any commercial port, and as the Baltic was frozen, the work must have been deferred till the following spring, had not the marine department given permission to take all the pieces of large dimensions from the Arsenal of Brest.

Then the work went on, notwithstanding the bad season. The carpenters worked under a large shed raised near the approaches of the bridge. At the same time all the irons which had been saved, were repaired in a forge near the workshop, and new ones made when wanted. In three months, all was ready for laying the platform.

But this operation was retarded by another important one, which should have preceded this, but was suspended on account of the cold and rains. The coating of mastic and paint upon the cables had been torn away in many places; most of the ligatures had been bruised; some wires were injured or cut; so that this part of the suspension required a general renewal. Moreover, it was necessary to know the condition of the interior; so that arrangements had to be made for inspecting them throughout and repairing at the same time. All the ligatures were taken off, the painting scraped, and the bundles opened. Each wire was separately examined; those that were broken were joined; those that were loose were shortened; and after bringing them together, they were soaked in boiled linseed oil, thickened with an addition of litharge and lampblack. Then the ligatures were renewed, and the surface of the cables was covered with mastic, upon which were laid several coats of paint.

To attend to these details, a foot-bridge was made of the beams and joists of the old platform, and was suspended by iron rods, first to the two interior cables, and then to the two exterior; so that at each head of the bridge, one of the suspension bundles was completely free for work, while the other bore alone one side of the bridge.

Another matter delayed the establishment of the platform for a few days.

The friction rollers, as has been said, had slid upon their plates towards the sides of the porches; two of them bore upon the rim of the plate, and could not work. To restore them to the first position, the two cables of the same head had to be raised at the same time. The difficulty lay in the insufficiency of the means, it being impossible to instal a powerful apparatus, or to find a solid place of support.

After vainly trying great levers and an iron wedge moved by a strong screw, they finally used very tapering wood wedges, well tallowed, and with great difficulty succeeded in introducing them between the cables and masonry, and were five days in restoring the rollers to their true place.

The roadway was finished in less than a month, and on the 20th May, 1853, the bridge was ready for travel.

*Change in the System of Mooring Cables.*—The new galleries are 4·6 ft. wide and 6·5 ft. high. They have two masonry abutments against the rock, upon which rests a small brick arch, 4·3 ins. thick, with 6 ins. rise. The face of the walls is of rough hewn ashlar, except at the end cross gallery, where the cables embracing the masonry, it seemed best to line them with cut stone, so as to distribute upon a great surface the pressures borne by the pillow-blocks.

Upon this arch is a lining of Portland cement, arranged so as to form on each side of the axis, at their junction with the abutments,

canals to conduct the water filtering through the rock into vertical wells emptying outside the gallery. The oozings along and behind the masonry arrive through outlets into the cement gutters made at the foot of the abutments, through which they run to the discharge canals.

Between the arches and the top of the excavations, a space is reserved for a workman to pass from one side of the bridge to the other, and attend to whatever repairs may be needed.

The bottom of the gallery is covered with a masonry pavement, 7·9 ins. thick, resting upon the rock; the slopes on the sides are quite steep, but to have diminished them would have required a greater length and depth of excavation, and it was thought best to make only indispensable changes of the primitive profile to save expense; for this reason, the steps of the old galleries were preserved, though it would have been preferable to have had a uniform and continuous slope throughout.

The mooring galleries are now perfectly sound, and the arches staunch as possible, and no leaking has occurred.

Instead of passing down the vertical wells, the mooring cables are now a prolongation of the retaining without interruption, and so form with the suspension cables two continuous lengths, embracing upon each bank the masses of rock which constitute abutments of great solidity. To accomplish this, it sufficed to connect one by one, with new wires, all the strands of the up-stream bundles with the corresponding down-stream strands, by carrying the wires round the circuit of the cross galleries, and giving them a constant and appointed tension.

The operation of repairing the mooring cables was simple, but required care and precaution.

*Preliminary Details.*—In the first place, the covering pedestals (whose presence obstructed the passing of the new wires from one side of the bridge to the other) were removed; then the retaining bundles were unligatured between the towers, and 30 ft. inside of pedestals, so that the 16 elements, of which each was composed, were perfectly free, and grouped in two rows.

On the up-stream side were placed two dynamometers suspended by hooks upon an iron wire, parallel to the direction of the cables; on this wire the dynamometer could be slid at will. The first was attached to the cord of a windlass (No. 1), placed in the lowest part of the up-stream gallery; the second (No. 2), to that of another windlass (No. 2), placed upon the roadway, on up-stream side, 23 ft. in front of pedestal entrance. Each was provided with a jointed nipper, closing by means of a ring upon the index rod of tensions. A framed horse was placed between windlass No. 2 and pedestal, bearing a pulley, over which passed the cord of windlass (No. 2), and upon its upper cross-piece was made fast one of the ends of the wire supporting the dynamometers.

*Joining the Wires.*—With these arrangements, it was easy to effect the change in the system of mooring. A cut was made in one of the

down-stream bundles, within limits of points 5 ft. above and 33 ft. below face of pedestal, and after taking away the defective portion, to the extremity of a wire was joined that of a new wire, by a common ligature. This wire carried round to the up-stream side was seized at the other end by the nipper No. 2, and stretched by the windlass No. 2, till the dynamometer indicated the appointed tension. A strand taken from a corresponding element upon the up-stream side, was cut at any point within the above-named limits, and stretched by the windlass No. 1. The old and new threads were then held together by iron vices, and allowed the removal of the dynamometers whilst the second junction was made. This done, they were left to themselves, after taking away the vices and breaking off the useless ends of the ligatures.

The two strands of the retaining cables thus bound, were first kept isolated from the elements to which they belonged, so that no friction might impede the action of the windlass, and care also was taken to see that no obstacle was in the way of the new wire, especially in passing the grooves of the pillow blocks.

*Order of Taking up the Wires.*—The conditions of the work indicated the order of taking up the wires. Thus upon each side, the interior bundles, or those nearest to the mooring masonry, were first worked by the elements Nos. 1 and 2, adjoining the masonry; then Nos. 3 and 4 were taken up, and so on till the end. But after having repaired the first eight elements of the inner cable, they were left alongside of the other eight, to engage upon the half of the outer bundles, and for this reason :—

The previous tension to which each old and new wire was to be subjected, was not absolutely fixed. As it was important to prevent in the essential parts of the suspension, movements which would attend any alteration of the normal equilibrium, an endeavor was made to maintain for the restored wires their primitive tension, which the usual formulæ for the establishment of suspension bridges would give as 178 lbs. for each. But this figure derived from data, the principle of which, the suspension weight, being but approximately known, there were reasons to fear that it might differ from the truth. Now, if the given tension were too small, all the restored elements would have been too slack, and would have taken a greater sagitta in the parabolic part. The opposite would have been the case with too great a tension, and therefore the repair of the cables might produce a sensible rise or fall at their summits, and so in taking up completely one of the retaining bundles before touching the adjoining, it would be impossible to determine in the suspension curves of the same side the differences in level which might compromise the solidity of the yoke bands to which the platform rods were attached.

It was to avoid or lessen this inconvenience that the retaining cables were operated upon alternately.

No appreciable movement occurred either during or after the repair, so that the adopted tension differed but little from that of the old wires. A difference of level, 1·57 inches, which existed between the

bundles of the down-stream head, was even reduced one-half in diminishing by 6·6 lbs. the tension to be given to the wires of the highest bundle, before joining them to the new wires.

The operation was effected first upon the right bank, and then upon the left, instead of taking hold of both sides at once. The fear of having at any moment too great inequalities of tension between the untouched wires of the old cables and the restored portions, caused the adoption of this course. Besides the economy and good execution of the work, it was more convenient to use the same apparatus and workmen, instead of organizing a second gang.

*Distribution of the Ligatures.*—The ligatures, 1400 in number for each retaining cable, were distributed as uniformly as possible over a length of 33 ft. at the head of the pedestals. They were so completely lost within the bundles, that it is now difficult to distinguish their position; care was taken to cover them with a thick coat of red lead.

*Placing the Wires upon the Pillow-blocks.*—When the new wires crossed the pillow-blocks, they were placed in the grooves in regular and successive sheets, and were coated with red oxide of iron, or greasy substances, and care was taken to see that no friction or other cause should prevent the wires from receiving their proper tension.

*Preparatory Tension.*—Independently of this tension, which was fixed at 178·6 lbs., the wires were first subjected to another of 264·5 lbs., in order to overcome accidental resistances, and to destroy in part the bends existing in them.

*Dynamometers.*—The dynamometers, which were graduated in kilogrammes from 50 to 150, indicated the working of the windlasses, so as to have the normal tension; they were composed of three springs in a brass cylinder, 4 ins. diameter and 15·75 ins. long. The springs were fixed at one end to the bottom of the cylinder, and hooked by the other to a rod under the action of the tension, and carrying an index, which gave the effort exerted upon the rod by its position upon the graduated scale.

*Condition of the Wires of the Old Cables.*—The condition of the wires has shown the urgency of the operation; upon both banks and near the points where the sheetings merged into the cables (33 ft. inside of face of pedestals), 950, or about one-sixth of the whole number of wires, were completely eaten or cut up by rust.

In the cross galleries, at the point where the mooring cables bend round upon their pillows, the alteration was not so great, but existed for a great length. All the strands were more or less attacked, and the results of trials made upon 18 of them taken at hazard from the old bundles, shows that their force had diminished 7·13 kil. per square millimetre, or 10145 lbs. per square inch, or 139 lbs. per wire.

*Removal of the Old Cables.*—When all the strands of the two corresponding elements had been cut and then united by new wires, the ends of the elements forming the assemblage of sheeting and cables were easily removed outside of the galleries; but not so for the mooring bundles; they could not be taken away till after the repairs of all the cables, and then only in tearing them by scraps.

*Alteration of the Galleries.*—It was necessary to wait for the completion of the galleries (from face of pedestal to 65 ft. inside), before the repairs of the cables could be completely finished; for till then, they were inaccessible, and, even under the new cables, the space was so restricted that it was very difficult to extract the upper bed of the rock.

*Working Gang.*—Nine workmen sufficed for all the details of renewing the wires: four for making ligatures and attending to the dynamometers, two for service of windlasses, and three for carrying the wires and their stowage in the pillows. This gang could replace per day from 50 to 55 wires of the old cables. Four and a half months were consumed in joining the 5600 new wires with the 11,200 old ones.

*Net Cost.*—The expenses were divided into two classes: those for enlargement and change of mooring galleries, and those for repairs and change of cables; the first came to $6400, and the last to $5600.

These figures are considerable; but it must be remembered that the space is 656 ft. with a width of 20 ft., and that there are four cables containing in all 5600 wires; that the workmen operated in exceptional circumstances, and, by reason of the contracted space, could not effect more than a half of what could be done in better conditions; that the enlargement of the galleries required large excavations of great hardness, and that the blasting had to be done partially and with care to avoid injuring parts to be preserved; and, finally, that the parts of the newly-constructed cables, presented a length of 71 yards.

To render an exact account of the cost of a similar renewal in the case of a bridge of common dimensions, it would be best to use the following elementary data:—

A yard of wire, No. 19, weighs ·01408 lb., and the pound, including the linseed oil varnish, is worth $7\frac{1}{4}$ cents; the joining of a new wire with two old ones, costs from 7 to 8 cents; the purchase of the dynamometers and tension windlasses, their instalment, and the peculiar dispositions called for in the renewal of the cables, may be set at from $80 to $100. In France, many of the toll bridges have but 14·4 ft. width between handrails for a span of from 65 to 131 yds., and consequently the bundles contain only from 1600 to 2000 wires. If such cables are to be repaired, for a length of 32·8 yds., without a change in the system of mooring, the cost would be:—

| | |
|---|---|
| For 2000 new wires, 32·8 yds. long, weighing 9269 lbs., at 7·25 cents, . . | $ 672·00 |
| For rejoining 2000 wires, at 8 cents, . | 160·00 |
| For removing and renewing ligatures, recoating and painting, . . | 80·00 |
| Additional expenses, . . | 88·00 |
| | $1000·00 |

If necessary to modify the arrangement of mooring cables by substituting accessible galleries for wells, or by displacing the cables to make them embrace masonry abutments, there must be added a sum which, according to the case, may vary from $3000 to $4000.

These operations may be effected without interrupting the travel.

*Objection made to this Mode of Repairing.*—It was objected by some engineers that the accumulation of a great number of ligatures in a small portion of the cables, would diminish the strength of the latter, and that the fine wire of which they were made would be impaired sooner than the other parts of the cables, and in time get rusted, so as to fail in their duty.

When it is considered that these ligatures are placed in the same conditions with those that serve to join the cable wires, the inconvenience, if it exists, is reduced to a simple increase of the chances of rupture of all the ligatures; for, as regards resistance, it matters not whether they are uniformly distributed, or united at the same point. Now, the new made part has upon each bank a length of 65 to 75 metres, and the mean length of the bundles of wires, Nos. 18 and 19, vary between 70 and 80 metres, so that the renewal of the mooring cables does not increase the number of ligatures by more than 800 for the 5600 wires taken up, and as the whole number is nearly 26,250, for the whole length of the two cables the proportion of the chances of injury due to the ligatures is but $\frac{800}{26250}$ or $\frac{1}{328}$. Moreover, these ligatures are less exposed to the effects of moisture than the rest of the cables, and are generally in good condition, even in the damaged parts. This is owing to coating them (at the time of making) with red lead or oil with litharge, which, lodging between the numerous circuits of the wires, adheres more strongly and lasts longer than upon the smooth surface of wires Nos. 18 and 19, besides remaining intact, while that which protects the other is often injured at the workshop, or whilst being put in place.

Besides, experiments made upon 18 strands taken from the old mooring cables, which had been left 18 months among the refuse of the workshop, show that on being stretched even to rupture, not one of the ligatures failed, even though the wires supported as a mean 1256 lbs.; one of them was only broken by a weight of 1500 lbs.

*The Two Supplementary Cables.—Arrangement of Cables.*—The two supplementary cables form a continuous skein, embracing on each bank the abutments against which the mooring cables rest, and containing each 1400 wires of ·014 sq. in. section.

Between the towers they describe above the old cables a parabolic curve with 47·89 feet sagitta, and their distance apart at the summit is $15\frac{3}{4}$ ins., and only $3\frac{1}{2}$ at the ends. Beyond the towers they follow the same line with the retaining and moving cables, midway, and nearly at the same level; however, at their passage over the upper suspension roller, or that opposite the river, they are directly applied upon the sheets of cables, and only are independent at 19·5 ft. from the axis of the towers.

These dispositions, demanded by local circumstances and by the imposed obligation of preserving the agency of existing works and of respecting the forms and proportions of the masonry, are not without their faults. It would have been better had the old and new cables been equidistant throughout the parabolic curve; but as, near the

porches, their separation could not exceed $5\frac{1}{2}$ ins., on account of the smallness of the openings which they penetrate, and as in so small a space there would be difficulties in removing and replacing the rods, whose forms had to be changed for suspension upon supplementary cables, they were obliged to relinquish the parallelism. On the other hand, it is to be regretted that the want of space did not allow a complete independence of the new cables from the others, for their overlaying causes considerable frictions which have sensibly constrained the displacements and reactions, which should be produced in the supplementary cables when charged with their load. This circumstance, though foreseen, but whose influence could not be appreciated because the change in the system of primitive suspension would necessarily occasion in the old and new cables inverse movements, the one independent, the other simultaneous; this circumstance, I say, prevented an exact determination of the position to be assigned to the supplementary cables when they were entirely free; so that the ultimate rise, which has been fixed at 48·21 ft., was but 47·89 ft., a difference of $3\frac{9}{10}$ ins.

*Suspension Rods.*—The rods of the supplementary cables only differed from the others in having a hook instead of an eye at the upper ends, embracing the new cable and fastened with wire No. 12.

*Cast Iron Bolsters.*—The new cables are separated from the old at the origin of the suspension curve by cast iron bolsters of an oval form and 3·28 ft. long. They rest upon the sheetings of the primitive cables at the site of the lower friction roller with an intervening layer of very thick mastic. Care was taken to give the most suitable form to the face of contact, and the relief of the sheetings was obtained by a lead plate, from which the moulds were made for each of the bolsters.

The cables were made in their place, the wires being left free, so that the regulating curve not being deranged, it was easy to appreciate the coincidence of each wire with those already in place. For the same reason the framed horses generally used to support the parts between the towers and mooring masonry were dispensed with.

*Various Details.*—This operation called for the removal of the upper portion of the porches, the openings for the passage of the old cables not being large enough for the introduction of a bundle of wire. The cut stone was deposited one side or in the chamber above the arches.

The moving of the wires from one bank to the other was effected upon the bridge, but the porches could not be turned, because the wires would be involved between the towers and the first rods, and so they were raised directly upon the porches.

Upon each bank, was placed above and corresponding with the sheetings of the old cables a windlass upon a frame, whose cord passed through a movable ring, fitted to the end of a wood swipe made to turn upon a horizontal axis in a vertical plane parallel to the direction of the cables; to this cord was suspended a lead cylindrical counterweight with a diameter greater than the ring.

To raise the wire, one end was attached to the counter weight, which in turning the winch is stopped by the ring, thus causing the bar to

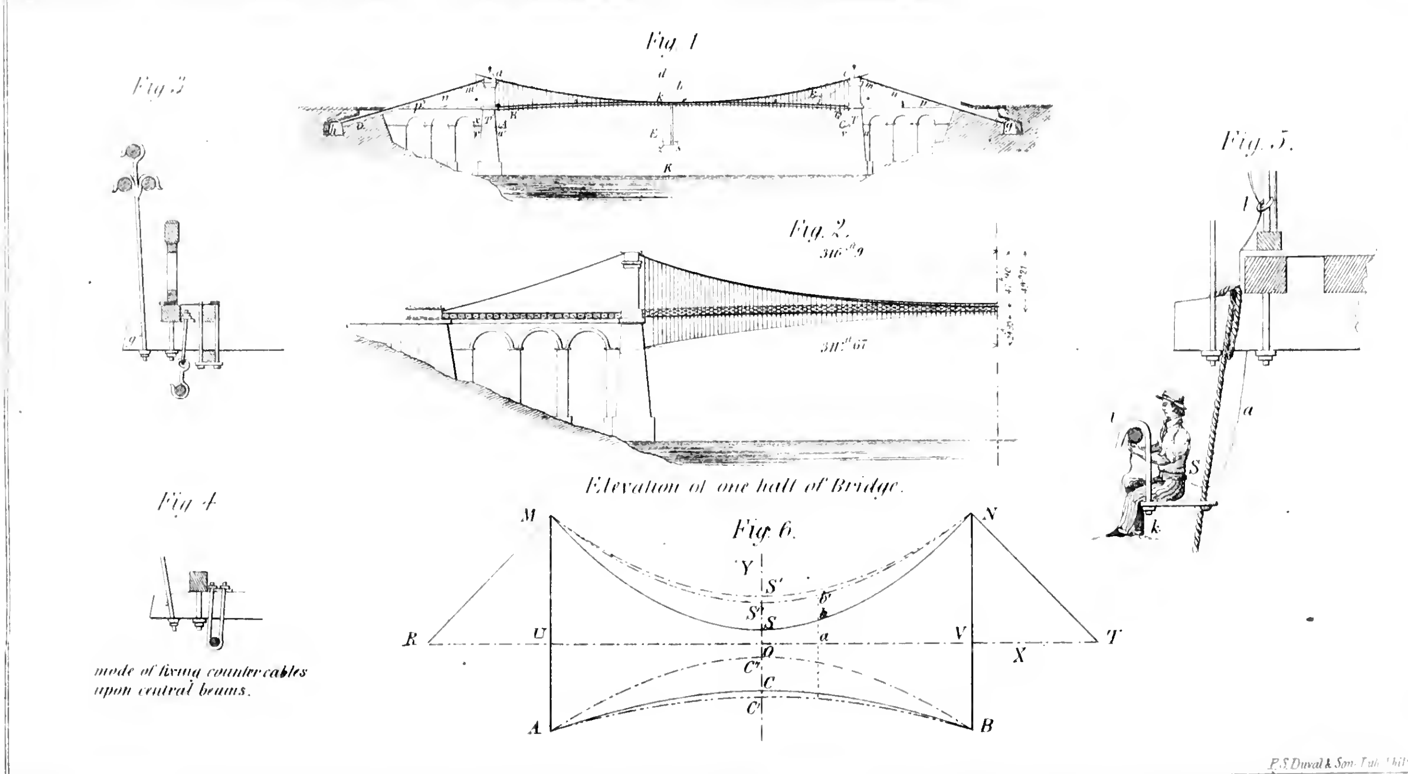
Fig. 1
Fig. 2.
316.ft 9
311.ft 67
Elevation of one half of Bridge.
Fig. 3
Fig. 4
mode of fixing countercables
upon central beams.
Fig. 5.
Fig. 6.
M
N
A
B
R
T
U
V
X
Y
S'
S''
S
O
C''
C
C'
a
b
b'

describe a quarter-circle and to pass from its horizontal position a little beyond the vertical, when by turning the winch in the opposite direction, the counter weight falls drawing the wire with it to the level of road-way. While the windlass is at work, the other end of the wire is united to the last hank unwound upon the other side of tower.

To diminish the frictions which might obstruct the separate movements of the new cable, the bolsters and sheetings should be well tallowed before laying on the wires. Each layer of wire is also to be covered with the same material.

When all the wires are laid on, they are brought together and soaked in linseed oil thickened with a small quantity of litharge and lamp-black; then, being bound by ligatures of wire No. 12 distributed with a space between them equal to their length, which is 11·8 ins., they are lined with a layer of thick mastic and three coats of paint.

*Previous Tension.*—When a wire is stretched for the first time, under a given weight, it experiences an elongation, which does not completely disappear, on becoming free; for loads between 2 and 24 kilog. per square millimetre, or from 2845 to 34150 lbs. per square inch, the permanent elongation is about $\frac{1}{3}$ of the primitive. Now the old cables, having experienced the transient tension of the test load, the new should be found in the same conditions, or subjected to a tension of 16·5 kilog. per square millimetre (23478 lbs. per square inch) or 330 lbs. per wire. For this purpose each wire, through the action of a windlass at both sides of the bridge, is made to describe the same curve as that of one (Plate III., Fig. 1, *a b c*) invariably fixed between the porches, and whose rise was determined so that under its own weight it would be sollicited by a horizontal force of 330 lbs.

The rise was deduced from the formula

$$\text{R} = \frac{p\,h^2}{2\,f\,\cos.\,a}, \text{ from which we have } f = \frac{p\,h^2}{2\,\text{R}\cos.\,a};$$

$$\text{now } \cos.\,a = \frac{1}{\sqrt{1 + \text{tang.}^2\,a}} = \frac{1}{\sqrt{1 + \left(\frac{2f}{h}\right)^2}};$$

$$\text{consequently, } f = \frac{p\,h^2}{2\,\text{R}}\sqrt{1 + \left(\frac{2f}{h}\right)^2}.$$

A relation which finally gives

$$f = \frac{p\,h^2}{2\sqrt{\text{R}^2 - p^2\,h^2}}.$$

Substituting in this expression $h = 316·93$ ft., R $= 330$ lbs., and $p = 0·04704$ lbs. per running foot of wire No. 19, we have for the rise of the indicating wire 7·2 ft.*

Thus prepared, the two supplementary bundles present in their provisional position a perfect regularity, and the summits of the curves are upon the same horizontal line. This is a new proof of the advantage of making the cables in place; this system being as easily and simply applied in small as in great spans, while the raising of the con-

* The author gives $f = 2·65$ m., which is erroneous; his data are $h = 96·6$ m., R $= 150$ k., and $p = 0·070$ k. per running metre. The curve, which is a catenary, is treated as a parabola.

stituent elements of cables for spans of more than 100 yards presents some difficulties, and the regulation of the different elements is not always attended with the desirable precision.

*Working Gangs and Cost.*—Independently of two agents whose special duty was to look after the perfect coincidence of the wires, there were 15 cablers or workmen who placed, per day, from 33 to 40 strands upon each head of bridge, that is to say, 31473 running yards of wire with a weight of 4411 lbs.

The daily wages of all these workmen came to \$8·00; so that the laying of the cable came to 0·18 cents per pound. This operation, without accounting for the special fixtures, would have cost double had the cables been made elsewhere.

*Provisional Sagitta.*—Before making the supplementary cable, it was important to determine precisely the provisional position to be given it, so that under a permanent load of $\frac{1}{3}$ of that borne by the two old cables on same side of bridge, it should take its definitive position in respect to the latter; in other words, to determine the sagitta of the wire which should regulate the placing of all the strands of the additional cable.

As this is an interesting matter, we give the steps by which it was resolved.

The rise was first assumed at 45·93 ft. (that of the cables being 49·21 ft.); then to verify it, it was left to find by what quantity it must be increased, if the regulating wire is loaded, for each running foot of its horizontal projection, with a weight equal to that primitively borne by each of the suspension wires.

The known relation* $$\left(\frac{2f}{h}\right)^2 = 6\left(\frac{c-h}{h}\right)$$

which may be written under the form

$$f = \tfrac{1}{2}\sqrt{3\,h\,(2\,c - 2\,h)} \qquad (u)$$

which gives the sagitta $f$ of a parabolic curve in function of its length $2\,c$ and of its chord $2\,h$, enables us to determine the variations of the rise corresponding with those of the curve.

On the other hand, if a wire such as $a\,k\,c$, with a length $l$, is loaded with a weight $p$ per running foot, in the part between the points of support, it experiences an elongation $a$, resulting from the horizontal tension Q, due to the load, and to the change in form of the catenaries $m\,n\,p$, $m'\,n'\,p'$, whose length diminishes, while the parabolic arc has an equal increase (Plate III., Fig. 1).

This elongation is expressed by the formula:

$$a = \frac{\text{Q}\,l}{\text{E S}} + \frac{2\,\sigma^2\,a^3\cos.\,\omega}{24\,q^2}\left(1 - \frac{\sigma^2}{(\sigma+p)^2}\right) \qquad (v)$$

in which:

$\sigma$ = the weight per running foot of wire No. 19 = 0·04704 lbs.
S = section of the same wire = 0·0000979 square foot.
$a$ = horizontal distance $o\,x$ between the ends of the retaining cables = 196·85 ft.

* Memoire de Navier sur les ponts suspendus, 2d Edition, p. 92.

Cos. $\omega = 0{\cdot}30$.

$E$ = co-efficient of elasticity = 4507552379 lbs. per sq. ft.

$Q$ = horizontal tension of each wire $= \dfrac{p\,h^2}{2f}$.

$q$ = tension of regulating wire under its own weight $= \dfrac{\sigma\,h^2}{2f}$.

Performing the calculation indicated in the expression ($v$) in substituting for $h$ 316·93 ft., 1246·74 for $l$, and 0·14112 lbs. for $p$, we have

$$a = 0{\cdot}4352 + 0{\cdot}1594 \times {\cdot}9375 = 0{\cdot}5846.$$

And as the value $2\,c$, corresponding to a rise $f = 45{\cdot}93$ ft. is

$$2\,c = 2\,h\left(1 + \frac{2f^2}{2\,h^2}\right)^{*} = 642{\cdot}72 \text{ ft.}$$

it follows that in putting $2\,c + a = 643{\cdot}28$ ft. instead of $2\,c$ in the formula ($u$) we obtain the length $P = 47{\cdot}40$ ft. of sagitta which the standard wire should take under the load $p$.

The space between the old and new cables having been fixed at 0·98 ft., this result shows that the provisional sagitta should be

$$49{\cdot}21 \text{ ft.} - (0{\cdot}98 + 1{\cdot}47) = 46{\cdot}76 \text{ ft.}$$

As, however, the preceding calculations have taken no account of the frictions of the wires upon their points of support, and as the formulæ rest upon hypotheses whose correctness has only been verified in certain limits, it seemed best by direct experiment to see if absolute confidence could be put in the indications of theory.

Consequently a wire No. 19 was stretched from $h$ to $g$ (Plate III., Fig. 1), describing the line $h\,n'\,a\,e\,c\,g$, loaded in the portion $a\,e\,c$ with a uniform weight, equal to that borne by each wire of the old cables; then, fixing fast the end $h$, it was stretched so that its summit $e$, being 0·98 ft. above the middle of the suspension cable, the two parts $h\,n'\,m'$ and $m\,n\,g$ should describe the same curves as the lower generatrices of the retaining bundles.

The wire being fastened at $g$, its load was removed. Its primitive form was changed, and the summit $e$ rose 1·67 ft., while the catenaries $m\,n\,p$, $m'\,n'\,p'$, were lowered beneath the retaining cables. This operation, many times repeated upon both sides of the bridge, always gave the same result to within from ·39 to ·78 of an inch.

Moreover, the wire when in the position $a\,k\,c$ was loaded with the same weight, and each time returned exactly to the position $a\,e\,c$.

The accordance of facts with theoretical deductions, and the consideration that the sagitta of a catenary (like that assumed by the supplementary cables during their construction) is shorter than that of a parabolic arc of the same length, caused the adoption for the regulating curve, of that described by the wire of experiment, and the provisional sagitta to be fixed at 49·21 ft. — (0·98 + 1·67) = 46·56 ft.

These operations were conducted on the supposition that the load of each new cable was equal to that borne by each old cable, while in

* The original has $\left(1 + \dfrac{2\,f^2}{3\,p^2}\right)$, probably a misprint.

reality it was but $\frac{2}{3}$ of it, and as within the limits considered, the elongations of sagitta may be regarded as proportional to tensions $\frac{2}{3}$ of the space $e\,k = 1{\cdot}67$ ft., or 1·115 ft. was taken for the lowering of the summit of the additional cable.

But at the same time, the inverse movement of the other cables was to be accounted for when they were relieved of $\frac{1}{3}$ of their primitive load, and the rise of their summit was supposed to be $\frac{1{\cdot}67}{3} = 0{\cdot}556$ ft.; so that the old and new cables would be $1{\cdot}115 + 0{\cdot}556 = 1{\cdot}67$ ft. apart.

(To be Continued.)

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For the Journal of the Franklin Institute.

*Iron Girder Bridge for the Boston and Worcester Railroad, over Watertown Road, in Brighton;* built by Wm. Adams & Co., Boston. By Edward S. Philbrick, C. E.

Though this structure differs in many of its details from any bridge of the kind hitherto constructed, the same ratio was used in the proportioning of the metal to the strains incurred as in other similar English and American structures, viz: a maximum tensile strain of four and one-half tons, and a compressive strain of four tons per square inch of section, incurred by a live load of one ton per lineal foot of track.

It consists substantially of three girders of the **I** form, supporting on their tops a floor and double-track railway, the girders being braced against each other in a thorough and rather peculiar manner.

The span is eighty-six feet and ten inches between bearings, approaching the limit where a tubular form would be preferable to a series of separate girders, and therefore requiring a degree of strength unusual in the **I** form of girder. The middle girder, having sometimes to support two trains at once, should they chance to meet on the bridge, is made proportionally strong and rigid, as fully proved by the test load, described below.

The great obliquity of the bridge (there being an angle of only 21° 30′ between the tracks and the abutments), while largely increasing the length and cost of both masonry and superstructure, is an advantage when compared with right-angled bridges of similar span, because each girder is here supported laterally by the abutment itself throughout one-third of its length.

The horizontal members at the top and bottom of the girders, devoted to resisting the compressive and tensile forces respectively, are all two feet in width, varying in thickness to conform to the strains to which they are subject. Their joints are spliced with plates of the same width, on both sides. They are attached to the vertical sheets or *web* by a four by four inch ($4'' \times 4''$) angle iron on each side of the latter, passing along the centre of the horizontal plates. The joints of these angle irons are also spliced with a patch of similar form.

All abutting joints are accurately planed, as well as all sides of the sheets forming the *web*.

The sheets of the web of each girder are $\frac{3}{8}$ths and $\frac{7}{16}$ths of an inch thick, seven and a half feet high, and six feet three inches in width between joints. These vertical joints are abutted and covered by a batten, 8 inches wide on each side, and secured by a double row of rivets. Outside of these battens, on each side, is a vertical angle iron with a base of three inches, and a projecting flanch of six inches width, secured by the same rivets with the battens. Each end of these angle irons is bent out like a knee and attached by two rivets to the top and bottom members of the girder. In the middle of each sheet, or midway between these kneed ribs, is another vertical angle iron on each side, of the same dimensions, to check the vibration of the sheets, the ends of these being off-set and riveted through the horizontal angle irons which form the connexions between the vertical member or *web* and the horizontal plates at top and bottom.

The method usually adopted for joining these web-plates to each other in other plate-iron bridges, is to place a T iron on each side of the joint, the head of the T forming the batten, and the stem forming the rib. Having found these T irons beginning to split in a number of English bridges, owing to the weakness of the iron along the junction of the head and stem of the T, and finding no T iron of sufficient strength rolled in this country or to be obtained from England at a moderate cost, I preferred the arrangement described above, which the event has proved to be a decidedly stronger joint than the English one, and, at the same time, a cheaper one in our market.

As the tracks lie above the girders, ample opportunity is afforded for diagonal bracing between them, to maintain their perpendicularity and check vibration.

The ordinary mode of applying this bracing and that practised by English and Canadian engineers, is to attach at intervals of about 10 feet diagonal strips of plate-iron to the vertical ribs, crossing each other like the letter X, and riveted together at their intersection. But the height of our girders being unusually great ($7\frac{1}{2}$ feet), as well as the horizontal distance between them (11 feet), these braces might flap and vibrate under express trains to such an extent as to bring undue strain upon their attachments and render them nearly useless. To obviate this, I formed each brace of two pieces of plate-iron, six inches wide and three-eighths of an inch thick, connected at right angles to each other by a $1\frac{1}{2}$ inch angle iron riveted to each, giving a section similar to an angle iron, six inches wide on each side of the angle. As the two members of the X are placed back to back, they are riveted together at their intersection. In order to get the strongest available attachment between these braces and the vertical ribs of the girders, that half of each brace which does not lie in a vertical plane was heated at the ends and each end twisted 90°, allowing it to be attached to the ribs alongside the other strip, with the plane of which it here coincided. The result has been fully satisfactory, for the passage of heavy trains at high speed produces far less vibration

than in many similar bridges which I have had the opportunity to examine, in this country, and in England and France.

The rivets are, with a few exceptions, all of one inch diameter, being heated and headed in the usual manner.

The rivet-holes were all *drilled*, being, as I believe, the first case of the kind in a work of this size. It can hardly be doubted that drilling secures a cleanness of cut, if not an accuracy of position, unattainable by punching. The drill neither disturbs the fibre of the iron near the hole, nor bends or stretches the plates like a punch: circumstances which often render it difficult for punched plates to be accurately fitted to each other, or to have that exact correspondence of holes which is indispensable to a first-rate joint.

This bridge is to be subject to a traffic of some forty-five trains daily, many of which trains weigh 400 tons. Previous to opening it to the traffic, it was tested as follows:

A large pile of iron rails was distributed over the floor, and a train placed on each track, weighing in all 159·3 gross tons. The deflections were carefully observed at the centre of each girder, the load then removed and a second observation taken, after which the load was replaced and again removed, with two more observations. The first loading produced a permanent set of 0·26 inches, a considerable portion of which may doubtless be attributed to the bearings on the abutments, where a white oak cushion, four inches thick, was interposed between the iron and masonry. The second loading of the bridge brought the girders down to exactly the same point as the first, the deflections being given below with the loads upon each girder. On removing the load, these deflections disappeared entirely.

| | Tons load. | Deflection. |
|---|---|---|
| North girder, . . | 37·15 | 0·39 inches. |
| Centre " . . | 79·65 | 0·33 " |
| South " . . | 42·50 | 0·45 " |

The unequal distribution of the load upon the north and south girders was due to the different weight of the engines placed on the two tracks, a difference which was not intended, but which served to show how nearly the deflections vary with the weights producing them, proving the great uniformity of the workmanship in the three girders, while the rigidity of the centre girder is shown to be fully equal to its double duty.

The materials used in this bridge were entirely of American manufacture. Before determining on the kind of plate-iron to be used, I availed myself of the kindness of Capt. Rodman of the U. S. Arsenal at Watertown, and the excellent apparatus under his charge, to test a variety of samples of boiler plate, with a view of comparing both their ultimate tensile strength and their extensibility when subjected to a tension increased by certain known degrees at will. I give the results of these experiments in the annexed tables, with a summary description of the kind of iron of which each sample was composed. The great uniformity of the lower grade of iron (3d experiment), together with its great tensile strength, authorized its use in our bridge wherever it could be introduced without change of form. Wherever

such change is required, however, I could not recommend it, as in the case of steam boilers, &c.

1st Experiment.—*Three pieces from same sheet.*

| Tensions per Square Inch. | First piece. Elongations. | | Second piece. Elongations. | | Third piece. Elongations. | |
|---|---|---|---|---|---|---|
| | While under tension. | After tension was removed. | While under tension. | After tension was removed. | While under tension. | After tension was removed. |
| 5,000 lbs. | ·00034 | ·00013 | ·00020 | ·00001 | ·00020 | ·00000 |
| 10,000 | ·00060 | ·00015 | ·00033 | ·00002 | ·00046 | ·00002 |
| 15,000 | ·00079 | ·00018 | ·00058 | ·00003 | ·00073 | ·00006 |
| 20,000 | ·00091 | ·00020 | ·00087 | ·00019 | ·00113 | ·00020 |
| 25,000 | ·00119 | ·00036 | ·00196 | ·00097 | ·00226 | ·00126 |
| 30,000 | ·00161 | ·00066 | ·01269 | ·01132 | ·01234 | ·01126 |
| 35,000 | ·00974 | ·00846 | ·03942 | ·03742 | ·02856 | ·02732 |
| 40,000 | ·03694 | did not recover | ·10942 | broke. | ·05060 | ·05060 |
| 43,580 | ·10800 and broke. | | | | broke at 42,800 lbs. pr in. | |

Note.—The elongations in all these tables are expressed in terms of the part measured, which was a strip of the plate 10 inches long, planed to a uniform section of about half a square inch; *i. e.* the first piece in the above experiment stretched about ·1 of its length before breaking, and bore a tension of 30,000 lbs. per inch, with a permanent elongation of only two-thirds of ·001 of its own length, &c., while the second piece stretched ·01 of its length by the same tension. A great part of the differences in the initial elongations may be attributed to the imperfection of the alignment of the bearings by which the specimens were attached—a difficult thing to avoid.

The iron used in this first experiment was from charcoal blooms entirely, known in the market as "best flanch iron," being warranted to turn flanches for boiler heads, &c., without cracking. The elasticity and strength under direct tension did not appear to be sufficiently superior to the iron used in the third experiment to warrant the difference in price, when used for purposes where no change of form was required. The specifications for our bridge called for this kind of iron, however, in cases where the form of plates was changed, the inferior grades not being able to endure such change without prejudice.

2d Experiment.—*Three pieces from same sheet.*

| Tensions per Square Inch. | First piece. Elongations. | | Second piece. Elongations. | | Third piece. Elongations. | |
|---|---|---|---|---|---|---|
| | While under tension. | After tension was removed. | While under tension. | After tension was removed. | While under tension. | After tension was removed. |
| 5,000 lbs. | ·00016 | ·00001 | ·00016 | ·00002 | ·00023 | ·00001 |
| 10,000 | ·00038 | ·00002 | ·00035 | ·00004 | ·00047 | ·00003 |
| 15,000 | ·00059 | ·00003 | ·00054 | ·00004 | ·00063 | ·00004 |
| 20,000 | ·00084 | ·00007 | ·00076 | ·00004 | ·00082 | ·00005 |
| 25,000 | ·00112 | ·00016 | ·00101 | ·00011 | ·00123 | ·00017 |
| 30,000 | ·00317 | ·00209 | ·00216 | ·00110 | ·00211 | ·00089 |
| 35,000 | ·01920 | ·01791 | ·02746 | ·02646 | ·01965 | ·01801 |
| 40,000 | ·02488 | ·02346 | broke at 40,100 lbs. pr in. | | broke at 39,900 lbs. pr in. | |
| 43,444 | broke. | | | | | |

The iron in this experiment was made from a mixture of charcoal blooms and blooms puddled with bituminous coal from charcoal pig.

From the uncertainty of the amount of each kind used in the mixture, and a reputation of want of uniformity, it was not considered worth the price charged as compared with the iron of the third experiment.

THIRD EXPERIMENT.—*Three pieces from same sheet.*

| Tensions per Square Inch. | First piece. Elongations. | | Second piece. Elongations. | | Third piece. Elongations. | |
|---|---|---|---|---|---|---|
| | While under tension. | After tension was removed. | While under tension. | After tension was removed. | While under tension. | After tension was removed. |
| 5,000 lbs. | ·00014 | zero. | ·00028 | ·00008 | ·00020 | zero. |
| 10,000 | ·00032 | " | ·00051 | ·00012 | ·00038 | ·00001 |
| 15,000 | ·00053 | " | ·00071 | ·00015 | ·00065 | ·00003 |
| 20,000 | ·00079 | " | ·00113 | ·00027 | ·00086 | ·00006 |
| 25,000 | ·00113 | ·00008 | ·00178 | ·00082 | ·00116 | ·00012 |
| 30,000 | ·00178 | ·00056 | ·00971 | ·00836 | ·00153 | ·00030 |
| 35,000 | ·01698 | ·01542 | ·02954 | ·02869 | ·00237 | ·00105 |
| 40,000 | ·04750 | ·04650 | broke at 38,000 lbs. pr in. | | ·01184 | ·00997 |
| 40,450 | broke. | | | | broke at 44,700 lbs. pr in. | |

NOTE.—A fourth piece from this iron bore 45,100 lbs. per inch.

The iron tested in this experiment was from "charcoal pig," puddled with bituminous coal and worked twice. Finding it possessed a high degree of elasticity, we adopted it for the bridge-work wherever the plates required no change of form.

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## *Observations on the Niagara Bridge.** By PETER W. BARLOW, Esq., C.E., F.R.S., F.G.S., &c., &c.

(Continued from page 93.)

### *Concluding Observations and Deductions.*

The preceding investigation leads to the inevitable conclusion, viz: that the Niagara Bridge, notwithstanding the defects which have been pointed out, is the safest and most durable railway bridge of large span which has been constructed. First, because it is less liable to deterioration; and, secondly, because the greatest strain to which it can be subjected is a less proportion of the ultimate strength of the supporting material.†

This stability is accomplished in a span of 820 feet by 400 tons of iron, and 600 tons of timber trussing and platform. Had wrought iron been used for trussing, from its superior rigidity the total weight of

* From the London Engineer, No. 253.

† The Fribourg Bridge, as appears from Weale's work on Bridges, has only one-quarter of the section and weight of cable in 870 feet span without any adequate means of preventing undulation, and has stood for 30 years. The durability of the Fribourg Bridge may therefore be doubtful, but it proves beyond question the stability of the Niagara Bridge.

material would not have exceeded 800 tons, the deflection of the wave reduced to 2 ins., and the strain on the cables to one-eighth of their ultimate strength.

It is clear, therefore, that 820 ft. is not the limit of the opening that can be crossed by this principle; it will readily be seen that spans as high as 3000 or 5000 ft. can be carried out for railways, without exceeding the safe limit of strain on the wire cables, and at a cost which would render remunerative connexions and communications which are now considered impracticable.

Navigable rivers may thus be crossed which at present depend for their communication upon ferries; as an instance of which, Liverpool and Birkenhead, and New York and Brooklyn, may be mentioned; and even in London, the sum expended on the Thames Tunnel would have made a useful public communication by this system; and the difficult question of over-crowded streets may be solved, as explained in my recent paper to the British Association, by viaducts of large span, which would interfere very little with the property on the surface.

The dimensions of a bridge to connect Liverpool and Birkenhead will be as follows:

| | | |
|---|---|---|
| Span, | 3,000 | feet. |
| Deflection, | 300 | " |
| Height of piers, | 450 | " |
| Section of cables, | 1,000 | inches. |
| Weight of cables between the piers, | 5,085 | tons. |
| Weight of suspension rod, | 300 | " |
| Weight of platform and girders, | 2,000 | " |
| Breaking weight of cable, | 48,000 | " |
| Strain at the point of suspension by weight of the bridge, | 11,077 | " |
| With a load of 1000 tons, | 12,577 | " |
| Weight of wrought iron in towers, | 6,000 | " |
| Estimated cost,* | £1,000,000 | |

The proposal to build a bridge of these dimensions may be somewhat startling, but let it not be condemned without a fair consideration. It must be remembered that the views here advanced are consistent with the opinions expressed by Telford; and such a proposition as is now submitted would have been received with less scepticism in the year 1814, when he projected the Runcorn Bridge, than it is at the present time, simply because the public have been taught (I believe erroneously) that girders and tubes are the correct principle of bridge construction.

The reasons why any structure is impracticable may be thus classified:—First, that they will not possess sufficient strength and durability when constructed; and, secondly, that it is impracticable to construct them.

The first question, of the strength and durability, is dependent upon the tensile resistance of the material employed. The wire used in the Niagara Bridge was tested by being strained over an opening of 400 feet, until the deflection was reduced to 9 ins.; this is equivalent to straining the same wire over a space of four miles, until the deflection is similar to that ratio proposed for the Liverpool Bridge.

* With piers in the river, a bridge of less cost could be constructed.

If the wire will support its own weight over an opening of four miles, it will evidently have a great excess of strength in three-quarters of a mile; in fact, it will be seen that, in the space proposed, the cables will support four times their own weight plus the greatest load on the bridge; and it would be made a condition of the contract that such strength of the cable should be tested *in situ* (by diminishing the deflection) to three times the strain to which it would be subjected. It will be found that the greatest strain on the metal of the towers, suspension rods, and stiffening girder will be $2\frac{1}{2}$ tons per inch, or $\frac{1}{8}$th of the ultimate strength. If these calculations (which may be checked by any person with a moderate mechanical knowledge) are correct, there can be no doubt of the direct strength of the bridge.

It may be supposed that a bridge of such large dimensions will oscillate with the wind, but it does not appear that oscillation (if by oscillation is meant swinging like a pendulum) is a complaint to which suspension bridges are liable; and if it was, this bridge, from having so much greater weight in proportion to the surface exposed to the wind, would be less liable to this evil, even if constructed with a timber platform in the ordinary way.

It is not generally known that several suspension aqueducts have been constructed with success in America, which, if liable to oscillation, could not long be maintained in condition.

The motion that is observed derives its origin from the undulations of the platform, produced by the agitation, unequal pressure, and change of the direction of the air in a hurricane, and it may be compared to the effect of the platform resting on the surface of water agitated by waves. If the platform has no longitudinal strength, it will undulate in every direction, and necessarily put the chains in a state of vibration, which may be mistaken for oscillation; but I have never detected that oscillation or swinging has occurred in a gale of wind, nor can I see how it is likely to occur. If the wind blew alternately in opposite directions at intervals corresponding with the time of vibration due to the suspension bridge, it would undoubtedly produce serious oscillation; but it does not act in this way. It is variable in some degree in force and direction, but still the general current over a large space will be in one direction, disposing the suspension chains to deviate to some extent from the perpendicular, but not to oscillate.

The observations of General Pasley and Mr. Provis confirm this view; and it is further confirmed by the fact, that no oscillation has been observed in the Menai Bridge (the chains of which being four in depth present a great resistance to the wind), since the longitudinal stiffening, small as it is, has been given to the platform. I will add nothing further to meet an objection that may not be raised, but if it is raised, there is no difficulty in showing that, if a bridge weighing 7500 tons is liable to be influenced by the wind, such a bridge as the Fribourg, with a timber platform, which weighs under 400 tons, in a span of 870 feet, would have been destroyed long before the year 1860.

There does not seem to me any other doubt or difficulty that can be

suggested with reference to strength and durability, and I will now consider the second question, whether there is any impracticability in constructing such a bridge.

The first step is to prepare foundations on each side of the river to carry 30,000 tons, a weight which has been much exceeded in masonry, and cannot be a difficulty.

The second step is to construct wrought iron towers 450 feet high. Masonry and brickwork having been carried nearly that height, it never can be argued that there is a difficulty in a tower of wrought iron 450 feet, with a section of metal allowing only $2\frac{1}{2}$ tons per inch compressure. If it was necessary, and the capital to execute the work, there is no difficulty in building an iron tower 4500 feet high.

We come to the fixing of the cables, which would be a question of some difficulty if chains were employed, but with wire cables the process is perfectly simple, and there is little more difficulty in 3000 ft. span than in 800—except that more powerful machinery is required; and the same may be said of the anchorage, which is a mere question of providing weight in proportion to the strain to be contended with.

The necessity of constructing the platform at such an elevation as to prevent the largest class of ships to pass under (for which 150 feet, or 50 ft. more than the Menai Bridge, has been allowed) is, no doubt, a great drawback to the usefulness of the proposed structure; but much less so than would appear at first sight. One-sixth of the steam power now used at a single ferry would raise all passengers with ease, and comfort, and safety, to the level of the bridge, and the inconvenience would be small compared with that of the uncertainty from gales, fogs, as well as danger of collision, which must always exist in a ferry situated as at Liverpool.

There is little doubt, in spite of the disadvantage, that the work would be of great public utility, and highly remunerative, as it would form a communication not only for passengers, but for road carriage, and by a street tramway would connect the railways on each side of the river.

I have only to add, (should it appear that preconceived notions are not so deeply rooted, that there is a hope of the subject being fairly considered,) that I am prepared, at my own cost, to make experiment on such a scale as will determine, not only that the direct strength is more certain than any previous structure, as every cable will be tested *in situ* to three times its strength, and nothing left for calculation: that the use of wire in the cables and wrought iron in the towers enables the work to be erected with facility and certainty, and moreover that the weight of the structure is so great in proportion to the moving load or force of the wind, the platform being of iron with a stiffening girder, that it is equally certain that the undulation observed in light suspension bridges will be avoided.

The span of the suspension bridge to connect New York and Brooklyn would not require to exceed 2000 ft. Having, therefore, investigated a larger span, it is not necessary to refer to the practicability of a bridge of less dimensions.

The utility of the suspension system girder to relieve the pressure of street traffic in London, will readily be comprehended. There are only three modes of curing an evil (which is becoming beyond endurance, if the business of the City is to be concentrated in the present small area). 1st, To widen the streets and build higher houses; 2d, To make roads or railways under the surface; and, 3d, To make suspension girders, of large span, over the surface. A fourth has been suggested, being street railways.

During my tour in the United States I traveled over between 40 and 50 miles of these railways in New York, Boston, St. Louis, and Cincinnati, and am of opinion that great public benefit will be derived from their introduction in England. A smooth iron road being substituted for paving-stones, the cars are less liable to concussions, and may be constructed much larger without greater weight of material, with height to stand upright, and space to walk with facility from end to end, when the seats are occupied. There results in consequence a degree of smoothness and comfort in traveling, which it is difficult to be understood by those who have only experienced a London omnibus. Cabs are unknown even in New York: if this system was carried out in the approaches to London very great benefit would be derived.

Still the pressure in the City, where the traffic is concentrated and the street narrow, would remain the same, and here the best way of dealing with the difficulty is, in my opinion, to carry the traffic on an upper level by suspension girder viaduct. Two lines of communication, one from east to west, and the other from north to south, would go far towards effecting the object, one commencing at the junction of the Tottenham Court road and Oxford street, passing at the back of the Bank to Whitechapel, and the other commencing at the Elephant and Castle, where the Kent, Newington, and Walworth roads unite, to a point near the Shoreditch station of the Eastern Counties Railway. The cost of a wire suspension girder viaduct with a span of 1000 feet would not exceed for a double line of street omnibus traffic (in connexion with the expected street railways, which will converge at the above described terminal point) £150,000 per mile, to meet fully the requirements of the Board of Trade.

The only land required will be for the wrought iron towers, as a wire bridge may be erected without the least interference with the intermediate property. Allowing £100,000 per acre (the average cost of the terminus of the South Eastern Railway) for the land required, or £50,000 per mile, the whole scheme may be carried out for a little above one million.

Two other applications: wire suspension bridges still occur to me, where bridges have been long projected and abandoned from their cost and interference with property, as hitherto proposed, viz: to connect Holborn and Newgate street by a level bridge, and thus avoid Holborn hill. A wire suspension bridge with towers of wrought iron, constructed like a vertical lattice beam, would offer little obstruction to the light, and would not exceed in cost the sum of £75,000.

The second is a bridge to cross the Mersey at Runcorn, where Telford

projected a chain suspension bridge in the year 1814, having a centre span of 1000 feet, with two side spans of 500 feet.

The construction of a chain bridge of these dimensions at that period was as much at variance with previous notions, and presented as much apparent difficulty as a wire bridge now presents of 3000 feet span, from the superiority of wires over chains, which is so manifest not only from its greater tenacity, but from the facility of erection, that large chain bridges will probably never again be executed.

The cost of a bridge at Runcorn, either for road or railway, with a section of metal such that the strain produced by the greatest weight will not exceed one-fifth of the ultimate strength of every part of the bridge, will not exceed £100,000, and responsible contractors will be found to execute the work for that sum, and probably much less.

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## APPENDIX.

### *Cornwall Railway—Saltash Bridge.*

Extract from Col. Yolland's Report, dated 25th April, 1859, previous to the opening of the line for traffic.

"I have been favored by Mr. Brereton, who has been acting as chief engineer in Mr. Brunel's absence, with certain particulars, that show the nature and strength of the structure, which are important and may be interesting.

"By the specification under which they were constructed, it is stipulated that the strain per square inch of section, with a load of $1\frac{1}{4}$ tons per foot lineal, should not exceed 4 tons; and with a load of $2\frac{3}{4}$ tons per foot lineal, it was not to exceed 5·5 tons per square inch.

"The west or first tube was accordingly severely tested by the engineers before it was floated to its proper position between the piers, preparatory to its being lifted to the required height by hydraulic pressure. The results were as follow:

"When the tube had to carry itself, and its portion of the bridge being, with the floor, about 1100 tons, the deflection observed at the centre was under $2\frac{1}{4}$ ins. on the east side, and $2\frac{1}{2}$ ins. on the west side, with a load of $1\frac{1}{4}$ tons per foot lineal uniformly laid on the roadway; the deflections were respectively 5·1 ins. east, and 5·25 ins. west, with the load increased to $2\frac{3}{4}$ tons per foot lineal, or 1200 tons; the deflections were $7\frac{1}{2}$ ins. east side, and $7\frac{3}{4}$ ins. west side; but it was noted that during the last two experiments the supports on which the tube rested had sunk about half an inch, which quantity must therefore be deducted from the preceding deflections observed with the load on. After the load of $2\frac{3}{4}$ tons per foot had been taken off, a permanent set of 1·2 ins. on the east side and 1·25 ins. on the west side was observed, beyond that resulting from its own weight, and caused by the heavy weights that had been applied on the roadway.

"On the 20th instant, the day being exceedingly favorable, with a spirit-level placed under the roadway, and resting on the iron stays at the central pier, I observed the deflections at these large openings produced by a load made up of two heavy engines near the centre, and

a number of trucks having their springs packed up, loaded with ballast, iron, &c., making up an aggregate weight of 384 tons, or as large a weight as can possibly be brought on the viaduct, unless the train is made up of a larger number of locomotive engines. The staffs observed were placed at the centres of each opening, and midway between the rails, and thus the deflections observed were the sum of all the deflections, including that of the cross girders carrying the roadway.

"With the above load, the east tube, &c. (not previously tested), deflected 1·14 ins. With the above load, the west tube (test already referred to) 1·20 ins.; and when the weight was taken off there was not the least indication of a permanent set. I then tried to register the deflection caused by passing the whole of this load over the bridge at a speed estimated at 30 miles an hour; but the spirit-level did not remain sufficiently steady to allow of the staff being read, but vibrated, as might be expected, as the train passed. I regard these results as highly satisfactory, and, so far as my knowledge goes, I believe them to be greatly superior to anything of the kind that has been attained elsewhere, and accomplished at less expenditure of money and materials.

"With a load of 1 ton per foot run, and not deducting for any portion of the ends of the tubes immediately resting on the piers, I estimate the amount of the strain on the trussed tubes at about 4·2 tons per square inch of section, and allowing 170 tons as the amount of this superincumbent weight not in any way trying the tube, the strain would be reduced to about 3·8 tons per square inch.

"The strain per square inch of section for the girders over the land openings is also in all cases less than 4 tons."

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## MECHANICS, PHYSICS, AND CHEMISTRY.

For the Journal of the Franklin Institute.

### *Particulars of the Paddle-wheel Steamer Ly-ee-moon.*

Hull built by the Thames Shipping Co., Glasgow, from the designs of a Mr. Ash. Superintendent of construction, Captain Hill. Engines were originally designed by Mr. Taylor, with Messrs. C. J. Mare & Co., during the existence of that firm at the Thames Iron Works, Blackwall. At the period of their failure, they were sold to the owners of this steamer and placed by them into the hands of Messrs. Seaward & Co., of the Canal Iron Works, where they were completed under the direction of Mr. Brunel of that firm. They were set to work under the inspection of Mr. Robert Galloway, to whom the greatest credit is justly due for the success which has been achieved. Boilers by Messrs. Mitchell & Co., Deptford, from Mr. Galloway's designs. Owners, Messrs. Dent, Palmer & Co., Hong Kong, China. Intended service, Hong Kong to Shanghae.

Hull.—Length at water line, 270 ft. 6 ins. Breadth of beam (molded), 27 ft. 3 ins. Depth of hold, 15 ft. 3 ins. Mean draft of water, 12 ft. Frames, of wrought iron plates. Tonnage, 1000 tons. Actual displacement, 1317·7 tons. Displacement per inch, between light and load lines, 12·74 tons. Area of mid-ship section, 282·6 sq. ft. Masts, three, of iron, intended to have been made available for the purpose of ventilating the ship, but are only partially successful.

Engines.—Two.—Oscillating. Diameter of cylinders, 70 ins. Length of stroke of piston, 5 ft. 6 ins.

Boilers.—Four.—Tubular. They are intended to work at a pressure of 25 lbs. per sq. in., and are fitted with Beardmore's admirable super-heating apparatus. These boilers are capable of generating more than sufficient steam under every contingency.

Paddle Wheels.—Diameter, 22 ft. The reefing floats are 10 ft. in length by 4 ft. 2 ins. in depth, giving 17 ft. 6 ins. diameter for the effective centres of floats, or 8 ft. 9 ins. from centres of wheel to centres of floats. They were constructed by Messrs. Seaward & Co., and are of great strength.

Remarks.—This vessel is intended, as stated above, for the China Seas, and is to be engaged in a trade in which the highest attainable speed, combined with economy of fuel, is rather the desideratum than cargo-carrying capacity. Her engine room is supplied with every modern contrivance for registering all manner of interesting facts in connexion with the performance of the engines, and telegraphs, clocks, counters, salinometers, &c., &c., are also there out of number. Silver's governor is fitted with the engine, and is said to work excellently. Messrs. James Taylor & Co.'s superior steam winches, with pumps combined, are to be seen on board in several places.

Coal being exorbitantly high in China, everything that assisted to reduce the consumption which these powerful engines will require, has been introduced in connexion with the boilers, and among them is the admirable invention of Mr. Mitchell, for removing the scale and other deposits that collect upon the interior surfaces of all marine boilers.

The speed attained by this steamer, during her first trial trip, was 16 knots per hour in still water, and during her voyage to the ports of her intended service, a few months since, she joined the U. S. Steam Frigate *Niagara*, and in a run from Puerto Grande to Hong Kong beat her sadly.

The cause of the erection of the *Ly-ee-moon*, and the aim to produce a vessel that could not be easily rivalled in speed, are summed up in the following:

The house of Messrs. Dent, Palmer & Co., the owners of this vessel, is one, if not the most extensive China house in Hong Kong. Their trade is in opium, although exchange, insurance, and silks are ostensibly their business. This firm have owned for years past the *Yang-tsze*, an American steamer 204 feet long, erected, as is well known, by Thomas Collyer, City of New York, and the machinery by the Morgan Iron Works. She plies between the same ports the *Ly-ee-moon* is destined for, carrying nothing but silks, opium, treasure, a few passengers, and the news,—principally, and almost entirely the latter. Captain Dearborn, who commands her, is an American, and receives all the perquisites for passengers, &c., for simply carrying the news in

advance of the regular mail, which he has never failed to do, from twelve to twenty-four hours.

By this means of obtaining the news brought to Shanghae by the Oriental steamships from India and the entire Eastern World, Messrs. Dent, Palmer & Co. are enabled to realize many thousands of dollars every mail, which is regularly twice a month.

The *Yang-tsze* would have continued to do all this business of carrying the news, &c., one steamer being sufficient, had not Messrs. Jardine & Co. (a rival house to Messrs. Dent, Palmer & Co.) constructed a steamer to beat the *Yang-tsze*, to be employed for the same purpose. To beat Messrs. Jardine & Co.'s vessel, the *Ly-ee-moon* was erected, with the view of getting the highest speed ever yet obtained from a sea-going vessel, and in this respect it is highly probable that the construction of it has admirably succeeded.

Before dropping this subject, a word or two more in relation to the steamer *Yang-tsze* may not be out of place. It is with much gratification we have learned that during her three years service in the China Seas, she has sometimes run right into the teeth of monsoons and typhoons, but always coming out perfectly safe and sound, and never has failed in a solitary instance to anticipate the mail. She has never broken down nor had one dollar's worth of repairing done to her whilst she has been running. Messrs. Dent, Palmer & Co. say that when they are done with her, they intend placing her in a glass case for exhibition. These facts reflect the highest credit upon its builders, and is another triumph for American ingenuity and American skill.

E. B.

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*Decision of the Hon. J. Dunlop, Chief Judge of the Circuit Court, District of Columbia, reversing the Decision of the Commissioner of Patents, in the matter of the Application of B. C. Smith for Letters Patent for an Improvement in Iron Pavements.* H. Howson, Counsel for B. C. Smith.

This is an appeal to me from the decision of the Commissioner, refusing a Patent to B. C. Smith for Improvements in Iron Pavements. Mr. Smith does *not* claim "fastening the plates or blocks of iron pavements by mortises and tenons or dowels, or their equivalents;" but his claim is in fact limited to a mode of laying such blocks of iron pavements as follows, to wit: An iron pavement composed of a series of plates laid a given distance apart from each other, and having projections and recesses so proportioned to that distance that the plates, when undisturbed, may form an unyielding pavement, and that one of the plates may be readily removed after a slight lateral movement of the adjacent plates, as herein set forth.

The question presented on this appeal lies within a very narrow compass. Mr. Smith claims to have invented a mode of laying pavements of iron, by which, without disturbing the body of the pavement, particular plates may be taken up and replaced at small cost, to lay down and repair in cities and towns, underground sewers, water and gas pipes.

Heretofore the iron plates, as shown in the references given by the Office, have been laid iron to iron, fastened together by tenons and mortises, so as to fit close, and therefore costly, and difficult to get up without fracture when the purposes above referred to called for their removal.

Smith's mode is to lay the plates about an eighth of an inch apart, and to proportion the mortises and tenons to that distance, filling up the interstices with sand, gravel, or earth, making, when so filled up, an equally solid and compact pavement. When a plate or plates are desired to be removed, the sand or earth in the interstices of the adjacent plates is picked out, which gives room by lateral pressure to take up the plates desired to be removed, without fracture of the plate or tenons, so as to get at the ground below, for laying or repairing sewers, water or gas pipes.

It is not denied by the Office that this contrivance is useful. Smith, it seems, offered to prove it, which was not insisted on, and its utility is apparent on inspection of the papers, models, and drawings. The Office refused to patent it, and the argument in substance of the Board of Appeals is, That the thing was obvious and within the reach of ordinary mechanical skill, and further, the elements were all old and well known.

This argument is answered by the fact that, though iron pavements have been introduced and patented as early as the year 1815, no such device, though useful, has heretofore been contrived by any mechanic who has laid such pavements.

That can hardly be said to be obvious which has taken so long a time to find out.

I agree, it is sometimes difficult to determine where ordinary mechanical skill ends and invention begins.

The best practical principle to guide the Office is that laid down by the Courts of Justice, and which must he regarded as settled Patent law:—That where the combination of known elements produces new and useful results to the public not before attained, then the person who discovers and applies the combination is the inventor within the true intent and meaning of the Patent law. I refer to Prouty & Mears *vs.* Draper, Ruggles, et al., 16 Peters, 336; Godson & Burke's Law of Patents and Copyrights, 63; Many *vs.* Geo. W. Lizer et al., D. C. Mass., in Jan. T., 1849, referred to in Commissioner Holt's decision in Phelan's case; Curtis on Patents, Sec. 24, 73, 94; Ryan *vs.* Goodwin, 3 Sumner's Report, 514, 518; my own decision in the case of Alburtus Laroue, 5th March, 1860.

The Commissioner in his answer to the reasons of appeal says: "Now it seems to me clear, that it is not patentable at this day to lay blocks of any material, to be held together by known fastenings at any given distance from each other, for any purpose."

This asserts the doctrine, if I rightly understand the Commissioner, that no combination of known elements of invention applied in a mode not before practised, however new and useful the results produced by

such combination, is patentable. The authorities I have cited are not in harmony with this position.

Again, the Commissioner in the same paper says: "The determined distance at which the plates shall be placed from each other, so that the change in this distance shall permit the removal of one or more, is a mere arbitrary measure adapted to the particular occasion; but to my mind this adoption of a determined distance to isolate a single plate of the series, is not an invention within the meaning of the Patent law, and derives no patentable novelty from its relation to the mode of fastening selected."

But the determined distance is not arbitrary, it is deliberate, and designed by the applicant, Smith, for attaining a useful purpose.

It is not adapted to the particular occasion only, but is meant for all occasions and all times where iron pavements are to be used; and whether it is patentable or not, I think, depends upon the question, whether the results produced are new and useful, and valuable to the public.

As these results are so new, useful, and valuable, I can see no reason why Smith should be denied a patent. He ought not to be so denied because his invention is simple. In the case of Ryan *vs.* Goodwin, Judge Story said: "The combination is apparently very simple. The simplicity of an invention, so far from being an objection to it, may constitute its great excellence and value. Indeed, to produce a great result by very simple means before unknown or thought of, is not unfrequently the peculiar characteristic of the very highest class of minds."

I sustain the Appellant's reasons of appeal, and do, this 21st December, 1860, reverse the decision of the Hon. the Commissioner of Patents of the date the 30th August, 1860. And I do further, this 21st of December, 1860, adjudge that a Patent be issued to Barzillai C. Smith for the Improvement in Iron Pavements, as claimed by him.

I return herewith to the Office all the papers, models, and drawings, with this my Opinion and Judgment, this 21st December, 1860.

JAS. DUNLOP, *Ch. Judge.*

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Translated for the Journal of the Franklin Institute.

## *On the Cementation of Iron.* By M. H. CARON, Captain of Artillery.

The processes in use in the arts for the cementation of iron, vary as to the nature of the cement, but all agree in the mode of operating: the piece to be cemented is put into a sheet iron box and surrounded by charcoal dust or soot, or charred leather or horn. Each mode is praised by those who employ it, but the explanation of the fact itself has hitherto remained unknown. While trying to explain the phenomenon, it occurred to me that the combination of the iron and carbon could only take place by means of a gaseous carburet, which might penetrate into the pores of the iron dilated by the heat, and there deposit its carbon. Now it appeared to me, that from the very nature of the cements, this compound must be a cyanide. In order to determine this, I made the following experiments:

The apparatus which I used consisted of a porcelain tube filled with charcoal in pieces of about 1 centimetre cube (0·064 cub. in.); along the axis of the tube was placed a square bar of iron, which was thus entirely surrounded by charcoal. This tube was placed in a reverberatory furnace, and heated with coke. When the apparatus was thus arranged, I passed through the tube heated to redness, successively, hydrogen, carbonic oxide, nitrogen, air and pure carburetted hydrogen. In no case after two hours of heating did I obtain any cementation: sometimes, in a few places, the surface of the iron was a little harder; but in every case, the superficial cementation could be attributed to the impurities of the charcoal or the gas.

When dry ammonia was passed through the tube, the result was different: the cementation was then rapid and excellent. After a two hours heat, the bar withdrawn from the tube, immediately tempered, then hammered to close the grain, then re-tempered, showed in its fracture a cementation of 2 millim. depth (0·08 in.), perfectly regular, and with a magnificent grain. To what cause was the cementation to be attributed? Evidently to the action of the ammonia on the charcoal: these two bodies at that temperature must have formed a gaseous cyanide of ammonium, which gave up its carbon to the iron and gave rise to the steel.

But this was only an hypothesis; I desired to establish directly the action of the cyanide of ammonium. For this purpose, I removed the charcoal in the porcelain tube, leaving the iron bar in the axis and supported at its ends. I prepared the cyanide of ammonium in a retort, and passed it through the porcelain tube while red hot. After heating for two hours, the bar was withdrawn and treated as before; it was perfectly cemented, and the end at which the gas entered was more so than the other. I therefore thought that I might conclude that in these experiments, the cementation was caused by the cyanide of ammonium.

It was not probable that the cyanide of ammonium should alone have this property; it was more likely that the other alkaline cyanides would act in the same way. The temper by the prussiate well known in the arts was a proof of this; unfortunately in this case, the cementation, which is only superficial, cannot be compared with the other.

I had therefore to employ other means to succeed in establishing the cementation by the alkaline cyanides.

My apparatus was arranged as before; the charcoal was soaked in a weak solution of carbonate of potassa; and I passed through the tube heated to redness, a very slow current of dry air. It is known that under these circumstances cyanide of potassium is formed, which is sensibly volatile at a red-heat. It was on the formation of this substance that I calculated to cement the iron. In fact, after two hours heating the bar showed a magnificent cementation of a depth of 2 millimetres.

Soda, baryta, and strontia cement nearly in the same way under the influence of a current of air. As to lime, it produced, as I expected, no cementation.

All the recipes in use for the cementation of iron may be explained by the formation of cyanides. The charcoal used always contains potassa or soda; the animal matters which are added, bring with the alkali the nitrogen which is to transform it into a cyanide.

In fine, it seems to me that these experiments show irrefutably that in order to obtain a rapid and deep cementation, the formation of the alkaline cyanides should be promoted in the charcoal surrounding the iron. The application of this truth will be very easy in the arts. We may perhaps be able, by this means, to diminish very much the time necessary for the process, and thus keep a much greater tenacity in the mass of the metal which the cementation has not reached.

*Annales de Chimie et de Physique*, October, 1860.

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*On the Melting-points of some of the Elements.* By WILLIAM CROSSLEY, Assay Master, Ormesby Ironworks, Middlesborough.

From the Lond. Chemical News, No. 35.

It is remarkable that in almost all the series or groups of the elements mentioned by Mr. Coleman there appears to exist a peculiar relation between the atomic weight and the melting point, which to a certain extent confirms his opinion that the equivalent number of an element expresses a certain amount of force, modified by its atomic volume. As an illustration we will take the group zinc, palladium, platinum.

| | At. Weight. | At. Vol. | Melting Point. |
|---|---|---|---|
| Zinc, . | 33 | 57 | 773° F. |
| Palladium, . | 53 | 57 | Highest heat of wind furnace. |
| Platinum, . | 98 | 57 | Oxyhydrogen blowpipe. |

Here we have a group of elements having a like atomic volume with an increasing atomic weight, not only decreasing in active chemical attraction, but decreasing in fusibility as the weight of the atom increase. Does the atomic weight here represent a force? We think so, because it appears general. Let us pass on to some other groups.

| | At. Weight. | At. Vol. | Melting Point. |
|---|---|---|---|
| Sulphur (crystallized), | 16 | 101 | 239° F. |
| Selenium, . | 40 | 101 | 420° |
| Lead, . | 103·7 | 114 | 617° |
| Silver, . | 108 | 128 | 1873° |
| Gold, . | 197 | 128 | 2016° |
| Chlorine (liquid), | 35·5 | 320 | Gaseous at com. temp. |
| Bromine, . | 80 | 320 | Liquid do. |
| Iodine, . | 127 | 320 | Solid do. |
| Aluminium, . | 14 | 66 | Red heat. |
| Chromium, | 27 | 66 | Agglomerate but not fuse at the highest heat of the wind furnace. |
| Molybdenum, . | 46 | 66 | |
| Tungsten, | 95 | 66 | |

Here we have four groups, in each of which the elements having the least atomic weight offer the least resistance, not only to the action of other elements, but also of heat. In so many groups, taken,

as it were, at random, it cannot all be accident. There are, however, exceptions: we find them in the groups

| | At. Weight. | At. Vol. | Melting Point. |
|---|---|---|---|
| Manganese, | 27·6 | 44 | Highest *heat* of wind furnace. |
| Iron, . | 28 | 44 | " " |
| Cobalt, . | 29 | 44 | " " |
| Nickel, . | 29 | 44 | " " |
| Copper, . | 32 | 44 | 1996° F. |
| Phosphorus, | 33 | 211 | 111° |
| Antimony, . | 129 | 224 | Red heat. |
| Bismuth, . | 213 | 270 | 507° |

Manganese and iron, and perhaps cobalt and nickel, follow this law, but copper varies very much; for this we can see no reason. Phosphorus and antimony follow the law, but bismuth comes between. What can influence it? Look at its atomic volume; it differs 59 from that of phosphorus. We cannot, therefore, be much surprised at its having a different melting point.

These facts support Mr. Coleman's views. The subject is interesting and well worth discussing.

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Translated for the Jonrnal of the Franklin Institute.

## *Mathematical Theory of the Dynamical Effects of Heat given to a Permanent Gas.** By M. J. Bourget, Professor of Mathematics in the Faculty of Sciences at Clermont.

Up to the present time, the theory of the motive power of heat has been treated, by assuming *á priori* the following propositions:—

*It is absurd to admit the possibility of creating either moving force or heat.*

*Heat cannot be made to pass from a colder to a warmer body.*

*In all cases where mechanical work is produced by heat, there is a consumption of a quantity of heat proportional to the work done; reciprocally, this quantity of heat may be represented by a quantity of mechanical work equal to that before spoken of.*

I am about to undertake the same subject in a different way, confining myself to the case in which a permanent gas is the vehicle of the heat.

It seemed to me that if the principles above mentioned are true; if it be true that heat and mechanical work may be regarded as homo-

* Works to be consulted on the question of the Mechanical Equivalent of Heat:—

Joule.— Memoir on the heating effects of magneto-electric currents; and on the mechanical equivalent of heat. *Annales de Chimie et de Physique*, Tome XXXIV.

Joule.— On the mechanical equivalent of heat.

Mr. W. Thomson.— Examination of Carnot's theory of the motive force of heat.

Clausius.— On the motive force of heat. *Annales de Chimie et de Physique*, Tome XXXV.

Quintus Icilius.— Memoir on the numerical values of the constants which enter into the expression for the heat disengaged by currents.— *Annales de Chimie et de Physique*, Tome LI.

Clausius.— On the motive force of heat. and on the laws resulting from it.— *Bibliotheque Universelle de Geneve*, Tome XXXVI.

Mr. W. Thomson.— Two memoirs on the dynamic theory of heat.— *Liouville's Mathematical Journal*, Tome XVII.

Reech.— General Theory of the dynamical effects of heat.— *Journal des Mathematics*, Tome XVIII.

See also the memoir entitled "A new system of Air Engine, deduced from a comparison of the systems of MM. Ericsson and Lemoine," by M. Reech.

geneous, and capable of being transferred the one into the other by equivalents; if, in one word, perpetual motion is impossible for hot-air engines as for others; this ought to be demonstrated, starting from known physical laws, and the formulæ deduced from these laws. I have not been deceived in my hope; and the mechanical equivalent of heat will here be seen deduced from the laws of Mariotte, Gay-Lussac, Dulong, and Regnault.

In another essay, in collaboration with M. Burdin, I studied the air machines, using the formulæ of Poisson which connect the pressures, densities, and temperatures of a given mass of gas, compressed or dilated, without being directly heated or cooled. Many of the consequences here noticed flowed from these formulæ. But it was not without hesitation that I assumed the formulæ of this illustrious mathematician as my base; the reasoning by which they were reached does not appear to me free from objection.

I have happily succeeded in removing this difficulty, and I have found a new and very simple demonstration of the same formulæ, which clearly shows the only hypothesis necessary to arrive at them.

Although confined to permanent gases, my analysis appears to me to give a certain degree of probability to that fruitful and seductive conception, the homogeneousness of the natural agents. Is it not, in fact, a thing well worthy of attention, that laws and formulæ found without any pre-occupation with the new principles, implicitly contain them?

SECTION 1.—Definitions and Preliminary Formulæ.

1. *Mathematical Representation of the State of a Gas.*

Three quantities determine completely the state of a permanent gas: its elastic force ($p$); its volume ($v$); and its temperature ($t$). We shall express its pressure in kilogrammes per square metre;* its volume will be referred to the cubic metre, and its temperature measured in centigrade degrees. To fix the ideas, we may, in what follows, suppose the gas enclosed in a cylinder of a square metre cross section, beneath a movable piston without weight, and always loaded with a pressure equal to its own elastic force.

Between these three variables, $p$, $v$, and $t$, there is a relation resulting from the laws of Mariotte and Gay-Lussac combined; for by denoting by $p_0$, $v_0$, and $t_0$ the values of these variables for another state of the gas, we have, $\frac{p\,v}{1 + a\,t} = \frac{p_0\,v_0}{1 + a\,t_0}$; whence, $p\,v = m(1 + a t)$ (1)

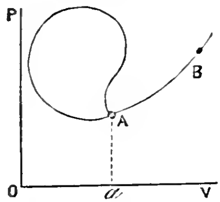
$m$ being a constant, and $a$ the co-efficient of dilatation, which is sensibly constant for all the gases. To determine $m$, make $t_0 = 0°$, call $\Pi$ the normal pressure of 0·76 referred to the square metre, and let us suppose that we are considering one cubic metre of gas at this pressure and temperature; then we shall have $m = \Pi = 10{,}333$ kil.; whence we obtain, $p\,v = \Pi\,(1 + a\,t)$. (2)

*The French units have been preserved in this translation. The kilogramme is 2·2047 lbs.; the cubic metre is 35·352 cub. ft., or 1·331 cub. yds. The square metre is 1·196333 sq. yds., or 10·767 sq. ft. The centigrade degree is equal to 1·8 Fahrenheit degrees. The millimetre is 0·039354 ins.; whence, 0·76 mil. = 29·9318·4 ins. The normal pressure used in England and in this country is 30 inches.

This is the form which we shall use in the subsequent calculations.

According to equation (2), it is sufficient to know the two quantities $p$ and $v$, in order to know the state of a gas. Let us then trace two rectangular axes, and let us take the volumes as the abscissas and the pressures as ordinates. It is evident that any state of the gas will be represented by a point such as A; a series of different states infinitely near each other will form a curve such as A B; if this curve re-enters itself and returns to its point of departure, it will form a *closed circuit.*

Fig. 1.

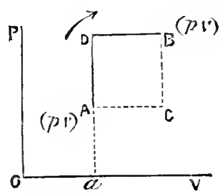



If we assume $\quad p\,v = \mathrm{H}\,(1 + \alpha\,t) = \text{const.} = \theta, \quad$ (3)
we obtain a hyperbola having for asymptotes the axes of co-ordinates; any point in this curve represents a state of the gas for which the temperature is constant.

2. *Expenditure of Heat in describing a rectangular closed circuit.*

Let A $(p\,v)$ be the initial state of a gas; by lines parallel to the axes, trace the closed circuit, A D B C A; cause the gas to pass through the different states which correspond to this circuit described in the direction of the arrow, and let us seek for the heat expended.

Fig. 2.




1. While the gas is passing from A to D, it is being heated under constant volume; the temperature $t_1$ is given by the formula $p'\,v = \mathrm{H}\,(1 + \alpha\,t_1)$, which, combined with $p\,v = \mathrm{H}\,(1 + \alpha t)$, gives $(p' - p)\,v = \mathrm{H}\,\alpha\,(t_1 - t)$.

The expenditure of heat will be $\quad q = \mathrm{D}\,c'\,(t' - t),$
D denoting the weight of a cubic metre of air at 0°, and $c'$ the specific heat under constant volume.

By substitution, this expression becomes $\quad q = \dfrac{\mathrm{D}}{\mathrm{H}\,\alpha}\,c'\,v\,(p' - p). \quad$ (4)

2. While the gas passes from the state D to the state B, it is being heated under constant pressure; the temperature $t'$ is given by the formula $p'\,v' = \mathrm{H}\,(1 + \alpha\,t')$, which combined with $p'\,v = \mathrm{H}\,(1 + \alpha\,t_1)$, gives $p'\,(v' - v) = \mathrm{H}\,\alpha\,(t' - t)$; the expenditure of heat is $q_1 = \mathrm{D}\,c\,(t' - t)$, $c$ being the specific heat under constant pressure.

This formula becomes by substitution, $\quad q_1 = \dfrac{\mathrm{D}}{\mathrm{H}\,\alpha}\,c\,p'\,(v' - v). \quad$ (5)

3. While the gas passes from the state B to the state C, it is cooled under constant volume; its temperature $t_2$ is given by the formula $p\,v' = \mathrm{H}\,(1 + \alpha\,t_2)$, which combined with $p'\,v' = \mathrm{H}\,(1 + \alpha\,t')$, gives $(p' - p)v' = \mathrm{H}\,\alpha\,(t' - t_2)$. The heat obtained will be $q' = \mathrm{D}\,c'\,(t' - t_2)$, or

$$q' = \frac{\mathrm{D}}{\mathrm{H}\,\alpha}\,c'\,v'\,(p' - p). \qquad (6)$$

4. Finally, while the gas passes from the state C to its primitive

state A, it cools under constant pressure; its temperature again becomes $t$ given by the formula $p\,v = \text{H}\,(1 + a\,t)$, which combined with $p\,v' = \text{H}\,a\,(1 + a\,t_2)$, gives $p\,(v' - v) = \text{H}\,a\,(t_2 - t)$.

The heat obtained will be $q'_1 = \text{D}\,c\,(t_2 - t)$ or by substitution, $q'_1 = \frac{\text{D}}{\text{H}\,a}\,c\,p\,(v' - v)$. (7)

In fine the expenditure of heat will be

$$\text{Q} = q + q_1 = \frac{\text{D}}{\text{H}\,a}\,[c'\,v\,(p' - p) + c\,p'\,(v' - v)]$$

the heat obtained will be

$$\text{Q}' = q' + q'_1 = \frac{\text{D}}{\text{H}\,a}\,[c'\,v'\,(p' - p) + c\,p\,(v' - v)]$$

The whole expenditure will therefore be

$$\text{Q} - \text{Q}' = \frac{\text{D}}{\text{H}\,a}(c - c')\,(p' - p)\,(v' - v)$$

As this quantity cannot be equal to 0, we reach this remarkable result:

*When a gas leaves any given state, it cannot return to it, after following a rectangular circuit of successive states, without the disappearance of a quantity of heat which is proportional to the surface* $(p' - p)\,(v' - v)$ *of the circuit.*

3. *Remark* 1*st*.—The preceding law proves that the quantity of heat necessary to pass a gas from one state A, to another B, depends not only on these extreme states, but also on the intermediate ones. It is, I believe, the first time that this truth has been shown by deducing it from the admitted laws of the action of heat upon the gases. In fact, I find in a condensation of the work of Clausius, by my friend M. Verdet (*Annales de Chimie et de Physique*, tome XXXV, p. 483), the following passages:—"When a gas passes from the temperature $t_0$ and volume $v_0$, to the temperature $t$ and volume $v$, it is generally admitted that the heat which it gains or loses depends only on the initial and final values of the temperature and volume. This is impossible if there be an equivalence between the mechanical work and the heat."

We see from the above process that it is not necessary to invoke any new principle for the purpose of proving this impossibility.

4. *Remark* 2*d*.—We might have followed the circuit in the opposite direction; there would then have been *gain* instead of *loss* of heat, and the quantity gained would still have been proportional to the area A $c$ B D.

5. *Remark* 3*d*.—Our reasoning shows that $a\,c\,c'$ depend neither on the temperature nor on the pressure. M. Regnault has established that $a$ and $c$ are subject to this law. As to $c'$ its determination is more difficult; MM. Gay-Lussac and Welter deduced from their experiments, that the ratio ($\gamma$) of these two specific heats is sensibly independent of the temperature and pressure, in the case of the atmospheric air; and it follows that $c'$ must be nearly invariable also.*

* At the same time, we do not think that much confidence should be given to this result. We shall therefore make no supposition as to $c'$, but shall place ourselves in such limits of temperature and pressure, as to allow $c'$ to be considered constant as well as $a$ and $c$.

6. *Remark 4th.*—If the point B is indefinitely approximated to A, the expenditure of heat approaches zero. In other words, to pass from the state A to another B infinitely near it, the same amount of heat must be expended whether you follow the route A $c$ B or A D B. The two expenditures are, omitting an infinitely small quantity of the second order,

$$Q = \frac{D}{H\,a}\,(c'\,v\,d\,p + c\,p\,d\,v).$$

7. *Effective work of the gas in describing the rectangular circuit.*

Supposing, as we have done, the gas to be in a cylinder of a square metre of cross-section, and under a piston always equilibriated. It is seen that the effective work along the path A B D is $W = p'\,(v' - v)$.

The resistance through the path B C A is $W' = p\,(v' - v)$.

Then the effective work of the gas through the whole of the closed circuit is $W - W' = (p' - p)\,(v' - v)$

and is therefore represented by the area of the rectangle formed by the circuit.

8. *Elementary Demonstration of the Principle of the Equivalent.*

If we compare equations (10) and (14) we deduce

$$Q - Q' = \frac{D\,(c - c')}{H\,a}\,(W - W').$$

The co-efficient under the vinculum is constant for the same gas, for the pressures and temperatures used. Let us make then $E = \frac{H\,a}{D\,(c - c')}$

and we shall have $Q - Q' = \frac{1}{E}\,(W - W')$.

Therefore, "*The quantity of heat lost is proportional to the effective work done, and reciprocally; so that to each calory* lost, corresponds an effective work produced equal to* $E^{\text{k m.}}$.

Therefore without disquieting ourselves to know what heat is, we may at all events say, *that every thing takes place as though heat transformed itself into mechanical force at the rate of* $E^{\text{k m.}}$ *for each calory lost.*

This number E may be called *the mechanical equivalent of heat;* assuming $H = 10{\cdot}333$ k; $a = 0{\cdot}003665$; $D = 1{\cdot}293187$; $c = 0{\cdot}2377$; $\gamma = \frac{c}{c'} = 1{\cdot}41$ (Masson). We find in round numbers $E = 424$ kilogrammetres.†

9. *Remark 1st.*—This number necessarily presents some uncertainty, since physicists are not all agreed as to the value of $\gamma$. This is the reason that we have only assumed only the whole numbers.

10. *Remark 2d.*—If the closed circuit had been described in the opposite direction, the work would have been resisting in place of effective; nevertheless the formula would not have changed and we should have reached the following conclusion:

* A *calory* is an unit of heat; as for instance the quantity of heat necessary to raise 1 kilogramme of a gas one degree of temperature.

† This, in English measure, is 773 lbs. raised one foot high per degree Fahrenheit.

"*The heat produced is proportional to the resistance of the gas in the proportion of* E k.m. *for each calory.*"

The first proposition includes both cases, provided we admit once for all, that a negative quantity of heat lost is that quantity of heat gained; and that a negative quantity of work done represents that quantity of resistance.

11. *Remark 3d.*—The demonstration which we have given of the transformation of heat into mechanical work, in this particular case, may be introduced into the elements of Physics; it moreover shows the method to be followed to verify experimentally the truth of all our considerations.

In fact: either *first* there is an equivalent of heat, and in that case the number E is mathematically constant; then for all the gases we shall have

$$\frac{a}{\text{D}\,(c - c')} = \text{const.} = \frac{a}{\text{D}\,c\left(1 - \frac{1}{\gamma}\right)};$$

and this law is mathematical. Besides, as $a$ is sensibly the same for all we must have $\text{D}\,(c - c') = \text{D}\,c\left(1 - \frac{1}{\gamma}\right) = \text{const.}$

Therefore: *in different gases, the differences of the two specific heats for the same weights, are inversely as their densities:* or taking the specific heats of equal volumes; *the difference of these specific heats is the same for all the gases.*

Moreover, Dulong proposed this law that equal volumes of different gases require the same quantity of heat to raise them the same number of degrees; this is the law of the specific heat of atoms. Therefore $\text{D}\,c =$ constant for a certain number of permanent gases; therefore for all these $\gamma =$ constant.

For the same gas, the absolute invariability of E requires the invariability of $c - c'$, and consequently that of $c'$, since $c$ is nearly invariable; and consequently that of $\gamma$.*

Or else, *secondly*, the equivalent E does not exist in the sense assumed by Clausius, Joule, Seguin, &c. In this case our formula will still remain for small intervals of temperature and pressures; but for every different interval the co-efficient E is different. In this case E = function ($p.\ t.$), and the preceding conclusions do not stand.

Thus we see that if we should succeed in proving that the ratio $\gamma$ is constant for the same gas, we should have made an important verification of the existence of a mechanical equivalent of heat.

Our calculations show plainly that this hypothesis of the invariability of $\gamma$ necessarily leads to the admission of the transformation of heat into mechanical work. This is the reason that this may be deduced from the formulæ of Poisson, which only assume this invariability.

* All these results were found by Clausius, as consequences of the hypothesis made *a priori* that there was a mechanical equivalent of heat.

For the Journal of the Franklin Institute.

## *Particulars of the Steamer Louisiana.*

Hull and machinery by Harlan, Hollingsworth & Co., Wilmington, Del.

HULL.—Length on deck, 147 ft. Do. at load line, 110 ft. Breadth of beam (molded), 27 ft. Depth of hold, 8 ft. Do. to spar deck, 15 ft. 6 ins. Length of engine and boiler room, 35 ft. Frames—molded, 3 ins.; sided, $\frac{3}{4}$ in.—apart at centres, 16 ins. Sketch of shape, |; depth, 3 ins. 9 strakes of plates from keel to gunwale; thickness of plates, $\frac{3}{8}$ and 5-16 in. Description of cross floors, 8 T, 14 ins. high. Depth of keel, 4. Diameter of rivets, $\frac{5}{8}$ in., double riveted. One independent steam, fire, and bilge pump. Two bulkheads. 8 fore-and-aft keelsons, 14 ins. high $\times \frac{3}{4}$ in. thick, T. Draft, forward and aft, 7 feet. Tonnage, 353·45. Area of immersed section at load draft of 7 feet., 160 sq. ft. Displacement at load line, 438 tons. Masts, three.—Rig, schooner.

ENGINE.—Inverted direct-acting. Diameter of cylinder, 32 inches. Length of stroke, 2 feet 4 ins. Maximum pressure of steam, 30 lbs. Cut-off at half-stroke. Maximum revolutions at above pressure, 84. Weight of engines, 43,334 lbs.

BOILER.—One—Return flued. Length of boiler, 18 feet. Breadth of do., 7 ft. 9 ins. Height do., exclusive of steam chimney, 7 ft. 3 ins. Weight do., with water, 35,760 lbs. Number of furnaces, two. Breadth do., 3 ft. 4 ins. Length of grate bars, 5 ft. Number of flues, above, 16; below, 10. Internal diameter of flues, above, $6\frac{1}{2}$ ins.; below, 2 of 16 ins., 8 of $8\frac{1}{2}$ ins. Length of flues, above, 13 ft. 4 ins.; below, 10 ft. 10 ins. Grate surface, 34 sq. ft. Heating surface, 843 sq. ft. Diameter of smoke pipe, 3 feet. Height do., above grates, 33 feet. Consumption of fuel per hour, 560 lbs.

PROPELLERS.—Diameter of screw, 8 ft. 2 ins. Length do., 4 feet. Pitch do., 15 feet. Number of blades, four.

Date of trial, December, 1860. C. H. H.

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For the Journal of the Franklin Institute.

## *Particulars of the Steamer Han-kow.*

Hull built by Thomas Collyer. Machinery by Morgan Iron Works, New York. Owners, J. M. Forbes & Bros. Intended service, Coast of China.

HULL.—Length on deck, 212 ft. Do. at load line, 210 ft. Breadth of beam (molded), 30 ft. 6 ins. Depth of hold to spar deck, 11 ft. 4 ins. Frames—molded, 14 ins.; sided, 7 ins.—apart at centres, 27 ins.; strapped with diagonal and double laid braces, $3\frac{1}{2} \times \frac{1}{2}$ in. Tonnage, 717. One independent steam, fire, and bilge pump. Area of immersed section at load draft of 7 feet, 176 sq. ft. Displacement at load line, 725 tons. Masts, two—schooner rigged.

ENGINE.—Vertical beam. Diameter of cylinder, 48 inches. Length of stroke, 12 ft. Maximum pressure of steam, 30 lbs. Cut-off at half-stroke.

BOILERS.—Two—Return tubular. Length of boilers, 20 feet. Breadth do., 11 feet. Height do., exclusive of steam chimney, 9 ft. 6 ins. Number of furnaces, two in each. Breadth do., 4 ft. 9 ins. Length of grate bars, 7 feet. Number of tubes, above, 64;

flues, below, 10 in each. Internal diameter of tubes, above, 5¼ ins.; flues, below, 8 of 12½ and 2 of 15½ ins. Length of tubes, above, 14 ft.; flues, below, 7 ft. 10 ins. Grate surface, 133 sq. ft. Heating surface, 4500 sq. ft. Diameter of smoke pipe, 5 ft. 10 ins. Height do., above grates, 32 ft. Consumption of fuel per hour, 740 lbs.

Paddle Wheels.—Diameter over boards, 29 ft. Length of blades, 8 ft. Depth do., 24 ins. Number do., 26.

*Remarks.*—Water-wheel guards fore-and-aft, half width.

Date of trial, January, 1861. C. H. H.

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For the Journal of the Franklin Institute.

## *Particulars of the Steamer Thomas Freeborn.*

Hull built by Laurence & Foulke. Machinery by Allaire Works, New York. Intended service, New York Harbor and Coast.

Hull.—Length on deck, 143 ft. Do. at load line, 140 ft. Breadth of beam (molded), 25 ft. Depth of hold to spar deck, 9 ft. Frames—molded, 14 ins., sided, 5 ins.—apart at centres, 16 ins. One independent steam, fire, and bilge pump. Draft, forward, 5 ft. 6 ins., aft, 6 ft. Tonnage, 305. Area of immersed section at load draft of 6 ft., 127 sq. ft. Displacement at load line, 345 tons.

Engine.—Vertical beam. Diameter of cylinder, 40 ins. Length of stroke, 8 feet. Maximum pressure of steam, 30 lbs. Cut-off—one-half. Maximum revolutions at above pressure, 30.

Boiler.—One—Return flued. Length of boiler, 22 ft. Breadth of do., 10 ft. 3 ins. Height do., exclusive of steam chimney, 9 ft. Number of furnaces, two. Breadth do., 4 ft. 5½ ins. Length of grate bars, 7 ft. Grate surface, 62 sq. ft. Number of flues, above, 16; below, 10. Internal diameter of flues, above, 9½ ins.; below, 2 of 19 and 8 of 12 ins. Length of flues, above, 15 ft. 3 ins.; below, 9 ft. Heating surface, 1457 sq. ft. Diameter of smoke pipe, 4 ft. Height do., 47 ft.

Paddle Wheels.—Diameter over boards, 20 feet. Length of blades, 7 ft. 6 ins. Depth do., 24 ins. Number do., 14.

Date of trial, January, 1861. C. H. H.

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For the Journal of the Franklin Institute.

## *Particulars of the Steamers Suffolk Co., and King's Co.*

Hull built by Roosvelt & Joyce. Machinery by Allaire Works, New York. Owners, East River Ferry Co.

Hull.—Length on deck, 143 ft. Do. at load line, 143 ft. Breadth of beam (molded), 32 ft. Depth of hold, at ends, 11 ft; at centre, 12 ft. Frames—molded, 14 ins., sided, 6 ins.—apart at centres, 24 ins. One independent steam, fire, and bilge pump. Draft, forward and aft, 6 ft. 3 ins. Tonnage, 500. Area of immersed section at load draft of 6 ft. 3 ins. 175 sq. ft. Displacement at load line, 555 tons.

Engine.—Vertical beam. Diameter of cylinders, 34 ins. Length of stroke, 9 feet. Maximum pressure of steam, 25 lbs. Cut-off, Sickel's adjustable.

Boiler.—One—Tubular return. Length of boiler, 21 ft. Breadth do., 10 ft. Height do., exclusive of steam chimney, 10 feet. Number of furnaces, two. Breadth do., 3 ft.

5 ins. Length of grate bars, 6 ft. 6 ins. Number of tubes, above, 134; flues below, 8. Internal diameter of tubes, above, 3 ins.; flues, below, 15 ins. Length of tubes, above, 17 ft.; flues, below, 8 ft. 8 ins. Grate surface, 46 sq. ft. Heating surface, 2400 sq. ft. Diameter of smoke pipe, 3 ft. 4 ins. Height do., 40 ft.

Paddle Wheels.—Diameter over boards, 19 ft. Length of blades, 6 ft. 6 ins. Depth do., 24 ins. Number do., 18.

Date of trial, December, 1860. C. H. H.

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Translated for the Journal of the Franklin Institute.

## *Fabrication of Sugar.*

At the meeting of the Academy of Sciences of Paris held 14th January, 1861, M. Dumas presented in the name of M. Emile Rousseau a memoir on a means of purifying vegetable juices, applied to the making of sugar. In consequence of the immense importance of this work, we publish an extensive analysis of it, for which we are indebted to the kindness of the author.

In the juices of the saccharine vegetables, that of the beet being taken for an example, we find always two kinds of organic substances which oppose the extraction of the sugar. The first belongs to the group of albumenoid and caseoid matters. It undergoes all the modifications which reagents exert upon the solutions of albumen and casein. The salts of lime, and lime coagulate it. But this latter, whether by its own proper alkaline action it dissolves a portion of the vegetable substance, and holds it in combination, as M. Frenay has lately shown; or whether it liberates potassa or soda, causes the juices treated by it to remain always alkaline after the action of carbonic acid. These two effects are even found united, and there results from them a subsequent change of the syrups, which is especially felt in the low products of the manufacture of sugar.

The second substance is a matter generally colorless as long as it remains in the cells of the plant; but very greedy for oxygen, coloring rapidly under the action of the air, modified very easily by oxidizing agents, so as to be either transformed into that well known brown substance which appears, when vegetable juices are evaporated, or entirely destroyed. This substance, indeed, when it is deprived of all the albumenoid matter, reduces by heat the salts of silver, the binoxide of mercury, &c. By the action of this last material, the solution even takes the natural tint which the juice possesses after long exposure to air.

These facts being established, the data of the problem of the simplification of the making of sugar may thus be stated: We must find, 1st, a substance, generally but slightly soluble, having the power of coagulating all albumenoid substances, without any injurious action either on the sugar, or on the health; which can easily be withdrawn from the juice in case a certain quantity should remain in solution; and finally

shall be of low price. 2d, Another substance, of an oxidating power, so to speak, limited; which may by its action either destroy the coloring matter or transform it into the brown substance and then absorb it; in short, shall add to this absorbing action the innocuousness and the low price of the former.

Sulphate of lime in whatsoever state it may be, natural or artificial (raw or calcined plaster), is the substance which appears to me to fulfil all the above indications better than any other material which I have studied. It is neutral, a condition which I regard as indispensable: without action on the sugar, but slightly soluble: it unites to the conditions of harmlessness and low price, a most remarkable property of coagulating the albumenoid matters of vegetable juices, of that of the beet in particular. This property is such that it requires but a relatively very small quantity of its solution to produce this effect. The operation of defecation can therefore be performed under these excellent conditions, and with but a small quantity of matter; the head is very firm, collects well, and the juice can be drawn off in a proper state of clearness. The sulphate of lime therefore removes perfectly all coagulable matter, but does not touch the coloring matter, so that after the separation of the head, the juice soon colors deeply.

Animal charcoal is almost without effect immediately after defecation; it removes only the matter which is already oxidized, for after its action, the juice whose coloration is much lessened, soon colors again. We want therefore an oxidizing agent which shall do in a short time that which the air produces at length, or which may so modify this substance as to destroy or absorb it. Among the numerous bodies which I have examined in reference to this point, and which I shall not now enumerate, the hydrated peroxide of iron presents superior advantages in all respects.

Thus, after having removed by the sulphate of lime all the coagulable matters of a saccharine juice, if we agitate it either cold, or heated to a temperature which must never reach ebullition with hydrated peroxide of iron, the filtered liquor passes altogether decolored, and purified from almost all the foreign matters which it contained. Besides this, the peroxide of iron, by that property, which all chemists know it to possess, of absorbing the alkaline and earthy salts, removes the small quantity of sulphate of lime which remained in solution. Thus the juice which after the defecation by the sulphate of lime, reduced the nitrate of silver, &c., causes no change in them after its contact with the peroxide of iron.

This juice when it comes from a plant in the normal condition, is, after this purification, perfectly neutral to test-papers, and may be kept in contact with the air for several days without undergoing the slightest alteration or coloration, which proves that all the matters which could act as ferments have been removed. It boils very well, and does not color even by the action of heat. The syrup when concentrated to the proper point possesses only that slight yellow tint which belongs to the purest syrups. It tastes well, is deprived of the saline and disagreeable taste which we find in all beet-syrups, and

preserves a remarkable fluidity and limpidity. The crystallization takes place easily and the crystals are white.

As a final proof of the good purification of the saccharine juice by this method, if we add to a boiled syrup a proper quantity of water to bring it back to 25° or 30° of the areometer, and in that state mix it with a large excess of alcohol at 90°, no cloudiness or deposit takes place even after several days; it no longer retains a trace of iron.

Henceforth, the making of sugar is reduced to these manipulations only: heating the saccharine juice in a boiler with some thousandth parts of sulphate of lime (natural plaster is the best); all the coagulable matters unite in a firm head; the clear juice separated from this, is then stirred with peroxide of iron. After the separation of the oxide, nothing remains to be done but to evaporate the water; that is to boil down.

The hydrated peroxide of iron must be in the state of a firm paste. A litre (quart) weighs about 1145 grammes ($2\frac{1}{3}$ lbs.); it contains from 70 to 80 per cent. of water. The quantity to be employed varies with the juice; it is never more than 8 or 10 per cent of the juice, which amounts to 2 per cent. about of the solid matter, the rest being water. After its action on the syrup it takes a black color, shrinks and separates easily from the liquid. After it has been used, it is only necessary to wash it with warm water, after having left it exposed to the air, in order to give the organic matter which it has absorbed time to be destroyed, so that the deoxidized portion may take again the oxygen which it has lost. It may be used, as is seen, over and over again indefinitely, and requires but little expense for its regeneration. This fortunate property renders the question of the quantity to be employed of but little importance.

I will add in conclusion, that even now, its price is much below that of animal charcoal, for it may be supplied at 5 or 6 f. per 100 kilog. ($8 to $12 per ton), and this price will doubtless be much reduced hereafter.—*Cosmos.*

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For the Journal of the Franklin Institute.

*Strength of Materials:* Deduced from the latest experiments of Barlow, Buchanan, Fairbairn, Hodgkinson, Stephenson, Major Wade, U. S. Ordnance Corps, and others. By CHAS. H. HASWELL, Civil and Marine Engineer.

No. 5.

(Continued from page 114.)

*Formulæ to Ascertain the Values and the Dimensions of Bars, Beams, &c., of Various Sections.* (By Thomas Tredgold.)

For a Square, Rectangle, Rectangle, the diagonal being vertical, and Cylinder, they are alike to those already given, substituting in the rectangles, for $b\ d^2$, $s^3$.

For a Grooved, or Double flanched, Open, and Single flanched beam they are as follows:

Grooved.  Open. 

1. *Fixed at one End.*

Weight suspended from the other, $\frac{l\,w}{b\,d^2\,(1 - q\,p^3)} = V \qquad \frac{l\,w}{b\,d^2\,(1 - p^3)} = V.$

2. *Fixed at both Ends.*

Weight suspended from the middle, $\frac{l\,w}{b\,d^2\,(1 - q\,p^3)} = V \qquad \frac{l\,w}{b\,d^2\,(1 - p^3)} = V.$

3. *Supported at both Ends.*

Weight suspended from the middle, $\frac{l\,w}{b\,d^2\,(1 - q\,p^3)} = V \qquad \frac{l\,w}{b\,d^2\,(1 - p^3)} = V.$

4. *Supported at both* Ends. Weight suspended at any other point than the middle, $\frac{m\,n\,w}{b\,d^2\,\overline{m + n}\,(1 - q\,p^3)} = V \qquad \frac{m\,n\,w}{b\,d^2\,\overline{m + n}\,(1 - p^3)} = V.$

5. *Fixed at both* Ends. Weight suspended at any other point than the middle. $\frac{m\,n\,w}{b\,d^2\,\overline{m + n}\,(1 - q\,p^3)} = V \qquad \frac{m\,n\,w}{b\,d^2\,\overline{m + n}\,(1 - p^3)} = V.$

Single flanched.

1. $\perp$ $$\frac{l\,w}{\frac{b\,d^2\,(1 - q\,p^3)\,(1 - q)}{(\sqrt{1 - q\,p^3} + \sqrt{1 - q})^2}} = V.$$

2. 3. 4. 5. For the other conditions of a bar, beam, &c., use the same formula as the above, multiplying the *Value* obtained above by 6, 4, 1, and 1, 5 respectively.

*p and q representing as follows:—the other symbols as in the preceding formulæ.*

$$\frac{\text{depth of groove}}{\text{whole depth of beam}} = p.$$

$$\frac{\text{whole breadth of beam} - \text{width of web}}{\text{whole breadth of beam}} = q.$$

*Transverse Resistance from End Pressure applied Horizontally.*

WROUGHT IRON.

7·5 feet in length; flanches, 6 × 3·5 inches × ·625 thick; area, 5·5 sq. ins.
50,000 lbs. produced no set.
58,240 " " a set of 1·75 inches.

WHITE OAK.

Rectangle 10 feet in length, 11 × 4·5 inches.
33,600 lbs. gave a deflection of ·375 inch.
50,400 " " " ·5 "
67,200 " " " ·625 "
and with 78,400 " it broke.

## Table of the Transverse Strength of Cast Iron Girders and Beams.

Deduced from the Experiments of Barlow, Hodgkinson, Hughes, Tredgold, &c., reduced to an uniform measure of

*One inch in Depth, one foot in Length, and Supported at Both Ends. The Stress or Weight applied in the Middle.*

| Section of Girder or Beam. | | Area of Flanches. Top. | Area of Flanches. Bottom. | Width of vertical web. | Depth of girder. | B'dth of girder. | Area of section in centre. | Length between supports. | Breaking weight at given length. | Breaking weight at length of one foot. | Strength per square inch of section. | Strength per inch of depth of section. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Sq. ins. | Sq. ins. | Inch. | Inch. | Inch. | Sq ins. | Feet. | lbs. | lbs. | lbs. | lbs. |
|  | Equal area of flanch at top & bot., | 1·75 × ·42 = ·735 | 1·77 × ·39 = ·69 | ·29 | 5·125 | 1·77 | 2·82 | 4·6 | 6700 | 30150 | 10768 | 2100 |
| | do. | 2·03 × ·515 = 1·045 | 2·03 × ·515 = 1·045 | ·50 | 2·04 | 2·03 | 2·60 | 4· | 4004 | 16016 | 6160 | 3000 |
|  | do. | 2·02 × ·515 = 1·045 | 2·02 × ·515 = 1·045 | ·51* | 2·02 | 2·02 | 2·59 | 4· | 2569 | 10276 | 3952 | 1900 |
|  | Area of sec. of top & bot as 1 to 2. | 1·74 × ·26 = ·45 | 1·78 × ·55 = ·98 | ·30 | 5·125 | 1·78 | 2·87 | 4·6 | 7460 | 33300 | 11563 | 2200 |
| | do. as 1 to 4. | 1·07 × ·30 = 1·32 | 2·1 × ·57 = 1·2 | ·32 | 5·125 | 2·1 | 3·02 | 4·6 | 8300 | 37350 | 12367 | 2400 |
| | do. as 1 to 6. | 2·33 × ·31 = ·72 | 6·67 × ·66 = 4·4 | ·266 | 5·125 | 6·67 | 6·4 | 4·6 | 26100 | 117450 | 18352 | 3550 |
|  | . . | | 2·27 × ·46 = 1·044 | ·37 | 5·125 | 2·27 | 2·76 | 4·6 | 8800 | 39600 | 14347 | 2750 |
| | | | 1·5 × ·5 = ·75 | ·5 | 3· | 1·5 | 2· | 3·1 | 5208 | 16058 | 8029 | 2650 |
| | | | 5 × ·3 = 1·5 | ·365 | 1·56 | 5· | 1·96 | 6·6 | 1120 | 7280 | 3714 | 2350 |
|  | . . | 1·5 × ·5 = ·75 | | ·5 | 3· | 1·5 | 2· | 3·1 | 4536 | 13986 | 6993 | 2300 |
| | | 5 × ·3 = 1·5 | | ·36 | 1·55 | 5· | 1·96 | 6·6 | 364 | 2366 | 1213 | 750 |
|  | . . | | 23·9 × 3·12 = 74·56 | 3·30 | 36·1 | 23·9 | 183·5 | 23·1 | 349440 | 8066240 | 43958 | 1200 |
|  | . . | | 1·5 × ·5 = ·75 | ·5 | 4·† | 1·5 | 1· | 3·1 | 6480 | 19980 | 19980 | 5000 |
|  | . . | 1·5 × ·5 = ·75 | | ·5 | 4·† | 1·5 | 1· | 3·1 | 2352 | 7252 | 7252 | 1800 |
|  | . . | 4 × 2 = 8 | | 2· | 4· | 4· | 12· | 6· | 5600 | 33600 | 2800 | 700 |
|  | . . | 6 × 1·5 = 9 | 8 × 1·5 = 12 | 1·5 | 9· | 8· | 30· | 11·8 | 45300 | 528500 | 17617 | 1900 |
| | | 5·1 × 2·33 = 11·88 | 12·1 × 2·07 = 25·04 | 2·08 | 30·5 | 11·1 | 90·8 | 27·6 | 174320 | 4793800 | 52795 | 1700 |

* Horizontal Web. † Depth of opening, 3 inches.

## Table of the Transverse Strength of Cast Iron Girders and Beams. (Continued.)

| Section of Girder or Beam. | Depth of Beam. | Depth of Metal. | Width of beam. | Dist. between top&bottom base. | Breadth of girder. | Area of section in centre. | Length between supports. | Breaking weight at given length. | Breaking weight at length of one foot. | Strength per square inch of section. | *Value* per inch of depth of section. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Inch. | Inch. | Inch. | Inch. | In. | Sq. in. | Feet. | lbs. | lbs. | lbs. | lbs. |
|  Rectangular Prism, | 2·012 | 2·012 | ·994 | | — | 2·025 | 5· | 1888 | 9440 | 4662 | 2350 |
|  Open Beam. | 2·51 | 1·97 | 1·005 | ·54 | — | 1·98 | 5· | 2468 | 12340 | 6232 | 2450 |
| | 3·01 | 2·01 | ·995 | 1· | — | 2· | 5· | 3084 | 15420 | 7710 | 2550 |
| | 4· | 1·97 | 1·005 | 2·03 | — | 1·98 | 5· | 4353 | 21765 | 10992 | 2700 |
| | 4·04 | 3·01 | ·771 | 1·03 | — | 2·322 | 5· | 5141 | 25705 | 11070 | 2750 |
| | 4·04 | 1·48 | 1·507 | 2·56 | — | 2·23 | 5· | 5147 | 25735 | 11540 | 2850 |
| | 4·07 | 1·56 | 1·525 | 2·51 | — | 2·35 | 5· | 6000 | 30000 | 12689 | 3100 |
|  Square Prism, Stress at side, | 1·01 | 1·01 | 1·02 | | — | 1·032 | 5· | 527 | 2635 | 2552 | 2500 |
|  Cylinder, | 1·122 | 1·122 | 1·122 | | | ·989 | 5· | 474 | 2370 | 2396 | 2150 |
|  Square Prism, Angle up, | 1·443 | 1·443 | 1·443 | | | 1·041 | 2·8 | 449 | 2269 | 2182 | 1500 |
|  Versed sine of arch. . ·8 | 1· | 1· | 1· | | | 1· | | | 1425 | 1425 | 1400 |
| do. 1·5 | 1· | 1· | 1· | | | 1· | | | 1945 | 1945 | 1900 |
|  Versed sine of arch, . ·8 | 1· | 1· | 1· | | | 1· | | | 501 | 501 | 500 |
| do. 1·5 | 1· | 1· | 1· | | | 1· | | | 315 | 315 | 300 |

## Comparative Resistance or Strength of Girders, Beams, &c., of Equal Sectional Areas and Depths.

| | Description of Girder or Beam. | Comparative Strength. |
|---|---|---|
|  | Rectangular Beam, . . . | 1· |
|  | Grooved beam, top and bottom flanches of equal areas, of uniform thickness of metal throughout, and the depth three times the breadth (Tredgold), . . . | 1·16 |
|  | Single flanched beam, width of flanch five-twelfths of height, width of rib one-half the depth of flanch (Watt and Fairbairn), . | 1.27 |
|  | Open beam, the space one-half the depth, . | 1·50 |
|  | Double flanched beam, area of top flanch, one-sixth of that of bottom; depth of top flanch, one-half of that of bottom; width of bottom flanch, one and a quarter times the depth of the beam (Hodgkinson), . . . | 1·66 |

*To ascertain the Transverse Strength, or the Loads that may be borne by Cast Iron Girders or Beams, of Various Figures and Sections when Supported at Both Ends, the Load applied in the Middle.*

*When the Section of the Girder or Beam is that of a Rectangle, a Grooved, Open, Single or Double Flanched Beam.*

RULE.*—Ascertain the resistance or strength of the rectangular solid, the dimensions of which are the depth and the greatest breadth of the beam, and subtract from it the resistance which would be offered by that part of the beam which is wanting to make it an uniform solid.

NOTE.—This rule is applicable to all cases when the flanch of the beam having the greatest sectional area is set below, when the beam rests upon two supports or is fixed at both ends, or set above when the beam is fixed at one end only.

When the case differs from this, an increase of metal, obtained by a reduction of the *Value* of it, can be estimated for the result of the resistance per square inch of section of beams, of various sections in Table, page 185, 6.

EXAMPLE.—What is the load that will break a Hodgkinson beam, of the following dimensions and 10 feet in length between its supports, the load applied in its middle?

| | | |
|---|---|---|
| Top flanch, . . . | $7 \times 1$ | inch. |
| Bottom flanch, . . . | $21 \times 2$ | " |
| Width of rib, . . . | ·8 | " |
| Whole depth of beam, . . . | 21 | " |
| Area of whole section, . . | 63·4 | " |
| Dimensions of rectangle, . . | $21 \times 21$ | " |
| *Hence*, $21^2 \times 21$ . . = | 9261 | " |

$7 - \cdot 8 = 6 \cdot 2$ *inches* = *width of space between both extremities of top flanch and rib.* $21 - \overline{2 + 1} = 18$ = *depth of space between top and bottom flanches.*

*Hence*, $18^2 \times 6 \cdot 2 = 2008 \cdot 8$.

$21 - 7 = 14$ = *width of space between both extremities of top and bottom flanches.* $21 - 2 = 19$ = *width of space above bottom flanch.*

*Hence*, $19^2 \times 14 = 5054$.

*Difference*, 7062·8

*And*, $9261 - 7062 \cdot 8 \times 4 \times 500$† $= 4396400$ = *difference of products of the square of the depth and the breadth of the parts wanting to complete the rectangle multiplied by four times the value of the metal, which* $\div$ 10 *for the length* = 439,640 *lbs.*

*In the example given above, the formulæ of various Authors give the following results.*

Hodgkinson.— $\frac{2}{3\,d\,l} \times (b\,d^3 - \overline{(b - b')\,d'^3}) =$ w in tons.

d *representing depth of beam*, d′ *depth to bottom flanch*, b *breadth of bottom flanch*, b′ *thickness of vertical web, all in inches*, l *length in feet, and* w *weight in tons.*

$\therefore \frac{2}{3 \times 21 \times 10} \times (21 \times 21^3 - \overline{(21 - \cdot 8) \times 19^3}) = 177 \cdot 55$, *which* $\times 2240 =$ 397,712 lbs.

Fairbairn.— $\frac{2 \cdot 166\,a\,d}{l} =$ w. *a* representing area of bottom flanch.

$\therefore \frac{2 \cdot 166 \times 42 \times 21}{10} = 191 \cdot 1$, *which* $\times 2240 = 428{,}064$ *lbs.*

* The utility of this rule, in preference to those of Hodgkinson, Fairbairn, Tredgold, Hughes, and Barlow, is manifest, as in the one case, the *Value* of the metal is considered, and in the other cases, the metal is assumed to be of an uniform value or strength, and when the range in this element, both in weight and cost, render it imperative that in a structure of iron of the highest transverse strength, the weight due to the requirements of dimensions of the lowest transverse strength should not be increased, and contrariwise.

The only variable element not embraced in this rule, is that consequent upon any peculiarity of form of section, as for instance, in that of the Hodgkinson, or like beams, when the area of one flanch, greatly exceeds the rest of the section, and this flanch is placed other than below when the beam rests upon two supports or is fixed at both ends, or than above when the beam is fixed at one end.

† Assumed breaking weight of the metal. In connexion with this, it is to be borne in mind, that the greater the area of the section of the metal, the less its strength, and the longer the beam, the greater the risk of a deflection from a flaw in its structure.

Hughes.— $$\frac{2\,a\,d}{l} = \text{W}.$$

$$\therefore \quad \frac{2 \times 42 \times 21}{10} = 176{\cdot}4,\ \textit{which} \times 2240 = 395{,}136\ \textit{lbs.}$$

$$\frac{1{\cdot}5\ \text{A}\,d}{2} = \text{W},\ \text{A},\ \textit{representing area of section.}$$

$$\therefore \quad \frac{1{\cdot}5 \times 63{\cdot}4 \times 21}{10} = 199{\cdot}7,\ \textit{which} \times 2240 = 447{,}328\ \textit{lbs.}$$

Barlow.— $$\frac{1{\cdot}13\ \text{A}\,d}{l} = \text{W}.$$

$$\therefore \quad \frac{1{\cdot}13 \times 63{\cdot}4 \times 21}{10} = 150{\cdot}4,\ \textit{which} \times 2240 = 336{,}896\ \textit{lbs.}$$

*Again*, experiments upon the breaking weight of girders of English cast iron have given the following results:—

DIMENSIONS OF GIRDERS.

| | 1 and 2. | 3. |
|---|---|---|
| Top flanch, | 3·25 × 1·25 ins. | 4·125 × 1·5 ins. |
| Web, | 1·25 | 1·5 |
| Bottom flanch, | 9· × 1 25 | 15· × 2·25 |
| Whole depth, | 22· | 24·25 |
| Area of bottom flanch, | 11·25 | 33·75 |
| Whole area, | 39·69 sq. ins. | 70·69 sq. ins. |
| Length between supports, | 19· ft. | 30·75 ft. |
| Breaking weight, | 1·116550 lbs.<br>2·125350 " | 3·145208 lbs. |

*Breaking Weights calculated by various formulæ.*

| | 1 and 2. | 3. |
|---|---|---|
| By Fairbairn, | 63,213 lbs. | 129,272 lbs. |
| " Hodgkinson, | 94,998 " | 139,082 " |
| " Hughes, | 58,352 " | 119,240 " |
| " Barlow, | 116,323 " | 141,120 " |
| " Rule,* page 187, | 114,337 " | 143,712 " |

COMPARATIVE VALUES OF CAST IRON BARS, HOLLOW GIRDERS, OR TUBES OF VARIOUS FIGURES (English Iron).

| | | |
|---|---|---|
| Square Bar, small, | | 1· |
| do, large, | | ·75 |
| Round Bar, small, | | ·675 |
| Square Tubes, | uniform thickness, | 1·075 |
| Rectangular do., | do | ·85 |
| Circular do., | do | ·90 |
| Elliptic do., | do | ·95 |

Determined by the formula, $\frac{\text{A}\,d\,\text{V}}{l} = \text{W}$, A representing area of section, and $d$, depth, *in inches*, $l$, the length in feet, and W, the load that may be borne with safety.

COMPARATIVE STRENGTH OF CAST IRON FLANCHED BEAMS.

| DESCRIPTION OF BEAM. | COMPARATIVE STRENGTH. | DESCRIPTION OF BEAM. | COMPARATIVE STRENGTH. |
|---|---|---|---|
| Beam of equal flanches, | ·58 | Breadth with flanches as 1 to 4·5, | ·78 |
| with only bottom flanch, | ·72 | 1 to 5·5, | ·82 |
| flanches as 1 to 2, | ·63 | 1 to 6, | 1· |
| 1 to 4, | ·73 | 1 to 6·73, | ·92 |
| Average experiment, | | | ·94 |

* The *values* here used, in consideration of the depth and great length of the girders, are reduced to 485 for the first and second cases, and 450 for the third.

## Table of the Transverse Strength of Wrought Iron Girders and Beams.

**Deduced from the Experiments of Barlow, Fairbairn, Hughes, &c., &c., and reduced to an uniform measure of**

*One Inch in Depth, One Foot in Length, and Supported at Both Ends. The Stress or Weight applied in the Middle.*

| Section of Girder or Beam. | Area of Flanches. Top. | Area of Flanches. Bottom. | Width of vertical web. | Depth of girder. | Breadth of girder. | Thickness of plates. | Area of section. | Length between supports. | Destruc. weight at given length. | Destruc. weight at length of one foot. | Strength per square inch of section. | *Value* for destruct. weight.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sq. ins. | Sq. ins. | Ins. | Ins. | Ins. | Ins. | Sq ins. | Ft. | lbs. | lbs. | lbs. | lbs. |
|  Solid, | 2·5 × 1 = 2·5 | 4 × ·38 = 1·52 | ·325 | 8·38 | 4· | | 6·295 | 11· | 12000 | 132000 | 20952 | 2500 |
| Solid, | 2·75 × 1 = 2·75 | 4·3 × ·42 = 1·806 | ·38 | 9·42 | 4·3 | | 7·596 | 10· | 22000 | 220000 | 28947 | 3000 |
|  " | 2·85 × ·38 = 1·08 | | ·31 | 2·5 | 2·85 | | 1·73 | 4· | 3142 | 12560 | 7260 | 2900 |
|  " | | 2·85 × ·38 = 1·08 | ·31 | 2·5 | 2·85 | | 1·73 | 4· | 3008 | 12032 | 6955 | 2750 |
|  Riveted, | 2·86 × ·33 = ·944 | 2·86 × ·33 = ·944 | ·66 | 3·7 | 2·86 | | 3·88 | 4· | 14000 | 56000 | 14433 | 3800 |
|  " | 5 × ·25 = 1·25 2 of 2·25 × 2·25 × ·3 = 2·82 | | ·54 | 2·6 | 5· | | 4·07 | 7· | 3355 | 23485 | 5770 | 2250 |
| do. inverted, | | 5 × ·25 = 1·25 2 of 2·25 × 2·25 × ·3 = 2·82 | ·54 | 2·6 | 5· | | 4·07 | 2·3 | 9250 | 20812 | 5113 | 2000 |
|  " | 2 of 3·5 × 3·5 × ·5 = 7 | 2 of 3·5 × 3·5 × ·5 = 7 | ·37 | 16· | 7·37 | | 19·92 | 24· | 32000 | 768000 | 38593 | 2400 |
| " | 2 of 2·125 × ·28 = 1·19 | 2 of 2·125 × ·30 × 1·29 | ·25 | 7· | 4·23 | | 4·23 | 7· | 24380 | 170660 | 40345 | 5800 |
|  " | | | | 3· | 1·9 | ·03 | ·29 | 3·9 | 672 | 2520 | 8689 | 2850 |
| " | | | | 3· | 1·95 | ·061 | ·60 | 3·9 | 2520 | 9450 | 15750 | 5200 |
| " | | | | 5·8 | 3·8 | ·065 | 1·24 | 7·6 | 3156 | 23670 | 19089 | 3200 |
| " | | | | 6· | 3·9 | ·1325 | 2·60 | 7·6 | 9976 | 74820 | 28777 | 4600 |
| " | | | | 6· | 4· | ·1325 | 2·62 | 7·6 | 10080 | 75600 | 28855 | 4700 |
| " | | | | 24· | 15· | ·124 | 9·60 | 30· | 12500 | 375000 | 39063 | 1600 |
| " | | | | 23·75 | 15·5 | ·272 | 21·20 | 30· | 51200 | 1536000 | 72452 | 3000 |
| " | | | | 24· | 15·5 | ·525 | 40·92 | 30· | 128900 | 3867000 | 94648 | 3900 |
| " | | | | 24· | 16· | ·525 | 41·45 | 30· | 128800 | 3864000 | 93221 | 3900 |
| " | | | | 36· | 24· | ·75 | 87·75 | 45· | 291200 | 13104000 | 149333 | 4900 |
| | | | | Feet. | Feet. | | | | | | | |
|  " | 9·6 × ·075 = ·72 | 9·6 × ·0743 = ·713 | | 9·5 | 9·5 | ·0743 | 2·86 | 17·5 | 3738 | 65415 | 22872 | 2400 |
| " | 9·6 × ·252 = 2·419 | 9·6 × ·075 = ·72 | | 9·5 | 9·5 | ·074 | 4·36 | 17·5 | 8273 | 146528 | 33607 | 3450 |
| " | 9·6 × ·076 = ·727 | 9·6 × ·142 = 1·363 | | 9·5 | 9·5 | ·076 | 3·54 | 17·5 | 3788 | 66290 | 18723 | 1950 |
| " | 9·6 × ·142 = 1·363 | 9·6 × ·076 = ·727 | | 9·5 | 9·5 | ·076 | 3·54 | 17·5 | 7148 | 125090 | 35619 | 3700 |
| " | 9·25 × ·149 = 1·378 | 9·25 × ·269 = 2·488 | | 18·25 | 9·25 | ·059 | 6·03 | 17·5 | 6812 | 119210 | 19768 | 1050 |

* The above and preceding results are deduced from girders of the length given; hence, when the length is less, the breaking weight may be increased, in consequence of the increased stability of the girder. These results are very conclusive of the correctness of the formula used, viz: $\frac{A\,d\,v}{l}$, as will be seen in the experiments here given.

### Table of the Transverse Strength of Wrought Iron Girders and Beams. (Continued.)

| Section of Girder or Beam. | Area of Flanches. Top. | Area of Flanches. Bottom. | Width of vert'l web. | Depth of girder. | Breadth of girder. | Thickness of plates. | Area of section. | Length between supports. | Destructive weight at given length. | Destructive weight at length of one foot. | Strength per square inch of section. | *Value* for destructive weight. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sq. ins. | Sq. ins. | In | Ins. | Ins. | Ins. | Sq in. | Ft. | lbs. | lbs. | lbs. | lbs. |
| | 9·25 × ·269 = 2·488 | 9·25 × ·149 = 1·378 | | 18·25 | 9·25 | ·059 | 6·03 | 17·5 | 12188 | 213290 | 35371 | 1900 |
| | 2·25 × ·26 = ·585 | 2·25 × ·26 = ·585 | | 15· | 2·25 | ·131 | 5·10 | 24· | 17600 | 452400 | 88700 | 5500 |
| | 1 × ·282 = ·282 | 1 × ·116 = ·116 | | 8· | 1· | ·067 | 1·47 | 11· | 12254 | 123794 | 84214 | 10300 |
| | 24·* | 12 8 | | 54· | 2·92 | | 45·82 | 75· | 125912 | 9443400 | 206096 | 3800 |
| Elliptical,† | | | | 24· | 16· | ·375 top, ·25 bot., ·125 side | | ·30 | 62720 | 188160 | | |
| " | | | | 36· | 24· | ·562 top, ·375 bot., ·25 side | | ·30 | 231465 | 6943950 | | |
| Tubes, | | | | 12· | 12· | ·0408 | 1·40 | 17· | 2600 | 44200 | 31571 | 2600 |
| | | | | 24· | 24· | ·095 | 7·13 | 31·27 | 9550 | 298629 | 41743 | 1725 |
| Elliptical, | | | | 14 62 | 9·25 | ·0416 | 1·56 | 17· | 2150 | 36550 | 23430 | 1600 |
| | | | | 15· | 9·75 | ·143 | 5·56 | 17·5 | 15900 | 278250 | 50045 | 3300 |

* Thickness of plates, bottom, ·156; top, ·147; sides, ·099. Area of bottom, 8·8 ins.

† The lateral strength of this was ascertained to be 38080, or $\frac{19}{31}$ of its vertical strength. The ultimate deflection was 2·75 ins.

## Results of Experiments upon the Transverse Strength of Wrought Iron Elliptical Tubes, English Iron, Fairbairn.

*Distance between the supports* 30 *feet; weight suspended in the middle.*

| Depth of tube. | Breadth of tube. | | Thickness of metal in inches. | | | Breaking weight. |
|---|---|---|---|---|---|---|
| Ft. | Ft. | ins. | Top. | Bottom. | Side. | lbs. |
| 2 | 1 | 4 | 3-8 | $\frac{1}{4}$ | 1-8 | 62,720 |
| 3 | 2 | | 9-16 | $\frac{3}{8}$ | 3-16 | 231,465 |

The ultimate deflexion was for the first, $2\frac{3}{4}$ inches.

The above and many of the preceding results are deduced from girders of the length of from 20 to 30 feet; hence, when the length is less, the breaking weight may be increased, in consequence of the increased stability of the girder.

These results are very conclusive of the correctness of the formula used, viz: $\frac{A\, d\, V}{l}$, as will be seen in the cases here given, in the 11th and 19th cases, where the relations between breadth, depth, and thickness are nearly identical, and in the 12th and 16th cases, where the

relations between breadth are the same, but the thickness and consequent area differ.

*To Ascertain the Transverse Strength, or the Loads that can be borne by Wrought Iron Girders, Beams, or Tubes, of Various Figures, and Sections when Supported at Both Ends, the Load applied in the Middle.*

RULE.—Divide the product of the area of the section, the depth, and the *Value* for the construction from the preceding table, by the length in feet, and the quotient is the destructive weight in pounds.

NOTE 1.—The rule given at page 187 for cast iron girders, &c , &c., will also apply here, when the metal is of such thickness as to give the girder, &c., full resistance to lateral flexure, and when the construction is such as to bring the stress upon the tension and compression of the metals, and not upon the rivets.

2. In determining the *Value*, the proportions of the construction in its flanches, width, and depth, &c., must be observed as well as the character of it.

3. The *Values* here given are based upon experiments with English iron.

EXAMPLE 1.—What is the load that will destroy a wrought iron solid grooved beam of the following dimensions:—

| | | |
|---|---|---|
| Top flanches, | $3 \times 1{\cdot}25$ | ins. |
| Bottom flanch, | $4 \times {\cdot}5$ | " |
| Width of web, | ${\cdot}4$ | " |
| Depth of beam, | $9{\cdot}$ | " |

$3 \times 1{\cdot}25 + \overline{4 \times {\cdot}5} = 3{\cdot}75 + 2 = 5{\cdot}75$ *inches, which* $+ \overline{9 - 1{\cdot}25 + {\cdot}5} \times {\cdot}4 = 2{\cdot}90 = 8{\cdot}65$ *inches* = *area of section.*

$$\textit{Then,} \quad \frac{8{\cdot}65 \times 9 \times 3000}{10} = 23{,}355 \textit{ lbs.}$$

EXAMPLE 2.—What is the load that will destroy a wrought iron plate beam of the following dimensions, and 10 feet in length between the supports?

| | | |
|---|---|---|
| Top flanch, | two of $3{\cdot}5 \times {\cdot}5 \times {\cdot}5$ | ins. |
| Bottom flanch, | two of $3{\cdot}5 \times {\cdot}5 \times {\cdot}5$ | " |
| Width of web, | ${\cdot}5$ | " |
| Depth of beam, | $17$ | " |

$$3{\cdot}5 \times {\cdot}5 \times 2 + (\overline{3{\cdot}5 - {\cdot}5} \times {\cdot}5 \times 2) \times 2 = 13 \textit{ inches,}$$

$$\textit{which,} + \overline{17 \times {\cdot}5} = 21{\cdot}5 \textit{ inches} = \textit{area of section.}$$

$$\textit{Then,} \quad \frac{21{\cdot}5 \times 17 \times 2400}{10} = 87{,}720 \textit{ lbs.}$$

EXAMPLE 3.—What is the load that will destroy a wrought iron rectangular tube of the following dimensions, and 10 feet in length between the supports?

| | | |
|---|---|---|
| Depth, | $25{\cdot}00$ | ins. |
| Breadth, | $16{\cdot}00$ | " |
| Thickness of metal, | ${\cdot}30$ | " |
| Area of section of metal, | $29{\cdot}64$ | " |

$$\textit{Then,} \quad \frac{29{\cdot}64 \times 25 \times 3500}{10} = 259{,}350 \textit{ lbs.}$$

*Formulæ for Beams and Tubes of Wrought Iron.*—(Fairbairn.)*

Solid Beams, $\frac{2800 \text{ A } d}{l} = \text{W}.$

Plate do., $\frac{2912 \text{ A } d}{l} = \text{W}.$

Cylindrical Tubes, $\frac{1792 \text{ to } 2800 \text{ A } d}{l} = \text{W}.$

Elliptical do., $\frac{1680 \text{ to } 5510 \text{ A } d}{l} = \text{W}.$

A *representing area of section, d the depth in inches, and l the length in feet.*

Hodgkinson.

Rectangular Beams, $\frac{60{,}000 \text{ to } 90{,}000\,(b\,d^3 - b'\,d'^3)}{3\,l\,d} = \text{W}.$

Cylindrical Tubes, $\frac{3{\cdot}1416 \times 22{,}500 \text{ to } 35{,}500}{\text{A}\ l}(r^4 - r'^4) = \text{W}.$

Elliptical do., $\frac{3{\cdot}1416 \times 29{,}000 \text{ to } 37{,}000\,(c\,b^3 - c'\,b'^3)}{\text{A}\ l} = \text{W}.$

*v, b', and d, d' representing the external and internal breadths and depths; r and r', the external and internal radii; and c c', and b b', semi-conjugate and semi-transverse diameter in inches; and l, the length in inches.*

COMPARATIVE VALUES OF WROUGHT IRON BARS, HOLLOW GIRDERS, OR TUBES OF VARIOUS FIGURES (English Iron).

| | |
|---|---|
| Square Bar, | 250 |
| Round do., | 195 |
| Rectangular Tubes, plates at top and bottom thick, at sides thin, | 425 |
| *Welded Tubes without Rivets.* | |
| Rectangular uniform thickness, | 375 |
| Circular do., | 325 |
| Elliptic do., | 350 |
| Circular Tubes riveted, | 190 |
| Rectangular do., | 280 |
| Elliptic do., | 250 |
| Flanched Beams, | 240 |
| Plate do., | 320 |

Determined by the formula, $\frac{\text{A}\ d\ \text{V}}{2} = \text{W}.$

* See Report of Commissioners on Railway Structures, 1849.

(To be Continued.)

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## *Aluminum Bronze.*

They are now testing at Manchester, the new bronze formed of 10 parts of aluminum and 90 parts of copper, to which M. Christofle called attention long ago. Its hardness is such that in a lathe making 2000 revolutions per minute, it requires six times as long to drill it as any other metal does.—*Cosmos*, September, 1860.

For the Journal of the Franklin Institute.

## *On the Economy resulting from Expansion of Steam.*

By Robert H. Thurston.

The experiments of Chief Engineer Isherwood at the Brooklyn Navy Yard, those now in progress on board the *Michigan*, at Erie, Pa., and others lately tried, seem to be making converts to the doctrine that the principle of the expansion of steam is of no practical value. I would like to offer a word or two in regard to these experiments, and also a few facts which seem to me to furnish quite as good evidence on the other side of the question.

The experiments on the engine of the *Michigan* show the consumption of fuel to be actually greater in proportion to the power evolved when "cutting off" at ·354, than when "following" full stroke.

At the time of the experiment under the first-named circumstances, however, the engine made but *nine revolutions per minute.* It is well known among engineers that a high speed of piston is required to enable an engine to work economically, *especially* when it is intended to obtain the full benefit of expansion. At this speed, the steam must have been refrigerated very effectually.

A writer, referring to the above experiment, in a late number of a journal devoted to engineering interests, remarks that a great gain by the use of a "cut-off" is all "moonshine," and, "engineers and scientific men have, for the last eighty years, subscribed to the greatest of fallacies," which assertion is supposed to be proved by *this single experiment.* As rebutting evidence, however, other well-known experiments of Mr. Isherwood himself may be adduced.

In his experiments on the smithery engine, at the Navy Yard, he found that by cutting off at ·22, sixteen per cent. was gained over its full stroke performance. The gain in economy, certainly, fell far short of that called for by theory, but it was a very perceivable gain, notwithstanding. That the engine was in a most wretched condition, was proved by its extraordinary consumption of coal (15 pounds per H. P. per hour).

In the same volume in which are given the details of this latter experiment, is also given the account of another experiment on a different engine, in which the gain by cutting off at ·28, amounts to nearly *thirty per cent.*

In this case, the consumption of coal at full stroke was 5·56 pounds per horse power, per hour, a vast improvement over the previous one, even when the difference in boilers is taken into account.

If, then, even these engines exhibit so great a gain, what may we not expect from engines in which the evils consequent upon uncovered pipes and cylinders, slow speed, long and contracted steam passages, slow closing of opening, and the many other circumstances especially detrimental to "cut-off engines," are avoided. The nearer we make our practice conform to theory, by providing against the interference of circumstances unrecognised by our theory, the nearer will our

practical results conform to our theoretical deductions. Mariotte's law provides that no heat shall be abstracted from the expanding vapor; hence, experiments conducted in a refrigerator should hardly be expected to be taken as proof of the falsity of that law. The unexpected discrepancy between theory and the result of experiment, should only render engineers more pains-taking in providing against adverse circumstances.

The most economical engine, not *specially* adapted to the use of steam expansively, that I have had occasion to test, is now running in this city. It was built by a Wilmington firm, and its valve is of the "long D" variety.

The engine runs night and day the week through. The engine room is very hot. Temperature of feed probably averages 150°. The steampipe is short, and the engine runs at a tolerably high speed. The circumstances all favor economy. The consumption of coal is *four* pounds per H. P. per hour.

The engine formerly required twenty per cent. more fuel than at present. The saving was effected by giving the valve more lap, and carrying steam high enough to bring the engine up to speed. Fig. 1, Plate IV, is an indicator card, taken after the change was effected. The change in direction of the steam-line at *a*, shows the point of cut-off.

The most economical engine of which I have knowledge, *built with special reference to the use of steam expansively*, is one of a class of engines now coming rapidly into use, known as the "Greene engine," and was built at Providence, R. I. It is running in circumstances very similar to the last mentioned, and is consuming *two and a quarter* pounds coal to the H. P. per hour. The great difference between the two engines in view of the amount of coal required, is readily accounted for by the vast difference in construction. An engraving of an engine of the latter form is given in Weissenborn's "*American Engineering Illustrated*."

The steam-chest in this engine is very large, and acts to some extent as a steam jacket. The valves are four in number, and are perfectly *flat*, thus avoiding liability to leak, either from wear or by warping under the action of the steam. They are placed at the ends of the cylinder, thus securing short steam passages, and are closed either by a spring or falling weight, thus obtaining a rapid movement. The regulator acts by determining the point of cut-off, which may vary from nearly full stroke to any fractional part of the stroke, and steam is thus let into the cylinder at nearly the boiler pressure. The cylinder is carefully covered to prevent radiation, and the *ensemble*, although probably capable of improvement, is, perhaps, the best engine now manufactured.

The comparison of the last two engines represents fairly, I think, the relative merits of the two classes. The *average* consumption of coal by engines as usually built, is probably between six and seven pounds per H. P. per hour, while that of engines built like the one last referred to, is certainly not above *three and a half* pounds with engines

of fifty horse power and upward. Figs. 2, 3, and 4, Plate IV, are indicator cards from Greene engines built at Providence, and exhibit tolerably well the merits of the machine.

The Cornish engine is universally acknowledged to be the most economical engine in the world, and in it the principle of expansion is carried to the greatest extent. One instance at least has been known where the consumption of coal was *less than a pound and a half,* and the *average* of these engines is but little over *two and a half* per H. P. per hour.

An English firm is building *marine engines,* which use about two pounds only per H. P. per hour, and in them the principle of expansion is carried almost to excess.

An excellent example showing the advantage of a good opening and the rapid closing of a cut-off valve, is presented by the working of the engine of the steamer *Armenia,* on the Hudson. The engine, a 40-inch cylinder of 14 ft. stroke, was built with "Steven's valve gear." Some few months since, she was fitted with E. R. Arnold's "Attachment," at a cost which certainly could not amount to $500. Figs. 5 and 6, Plate IV, are cards taken before and after the change. The effect of this added improvement was to decrease the consumption of coal more than a ton on each trip from New York to Albany. The point of cut-off is also now adjustable to any point from 4 feet to full stroke. Fig. 7, Plate IV, is from a fine engine having a "Sickle's cut-off," which was built and is now running at Providence.

Philadelphia, January, 1861.

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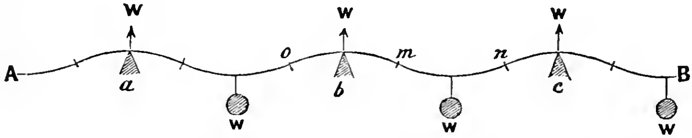
For the Journal of the Franklin Institute.

## *Strength of a Beam Fixed at Both Ends.* By Theo. Cooper, C. E.

The strength of such a beam, when loaded at the centre, is stated by many to be, when compared with a similar beam *supported* at both ends, as 3 : 2. .

By *theory,* however, it should be as 4 : 2, or 2 : 1.

In the case of a single beam, owing to the difficulty of perfectly fixing the ends, this theoretical result is not obtained; but there is a practical case in which we think it could be obtained, and would be of great importance:—that of a continuous beam extending over several points of support.




Let A B be such a beam, extending over several equidistant supports, *a, b, c,* &c., and loaded at the centre of the openings with weights, W.

The reactions at *a, b, c,* &c., will also be equal to W, and the convex portions, *o m,* of the beam will be equal and similar to the concave portions, *m n*; since both are acted upon by the same forces.

Evidently at the sections, *o, m, n,* of the beam, there will be no

strain of compression or extension, and were the beam separated at these points and the parts suspended from each other, the relation of the forces in the beam would not be altered.

This would divide the beam, A B, into a number of beams, with a length equal to one-half the opening, *a b*, and supported at the ends. The strength of each of these, representing the strength of A B, would be *twice* that of separated beams spanning the openings, *ab*, *bc*, &c.

We see, moreover, that the beam thus loaded would break at both the *centre* and *supports, simultaneously.*

If, however, we suppose the beam, A B, to be loaded *uniformly* over its whole length, the *reaction* then being greater than the force acting between the supports reduced to the centre, the relation of the forces will be different, and we shall have as follows:—

Representing the strain at the centre of the opening by 1,
that for the strain over the supports will be 2,
and that for the centre of a detached beam of the same span, will be 3.

A beam thus loaded would break *first* over the supports, and *then* at the centre; and its strength would be to that of a *supported* beam, of the *same* span and load, as 3 : 2. (Moseley says as 3 : 1, but he *assumes* it to break at the centre.)

The points, *o*, *m*, *n*, will be at a distance of 0·26289 of the opening from the supports.

This last case may be applied to a bridge continued over several piers, and supporting a distributed load, as a train of locomotives.

As we gain 50 per cent. in strength by thus continuing even a girder of uniform chords over the piers, we see the importance of considering these facts.

And in proportioning the chords to the strains, we would have very different results from the case of a single span; for in the parts, *o m*, of the girder, the position of the compressive and extensile forces, would be the reverse of that for the part *m n*; the chords should be the strongest over the piers, and decrease towards *o* and *m*, and then again increase to the centre, where the strength must be to that at the piers as 1 : 2.

When only one span is loaded, our assumption of a distributed load may still be considered as true, by making a proper application of a system of counter braces, to prevent the uprising of the unloaded spans.

When we have a girder extending over but two or three openings, our statements are subject to modification.

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## *On the Preservation of Platinum Crucibles.*

From the Lond. Chemical News, No. 49.

In connexion with some sensible remarks upon the use of sand in cleaning platinum crucibles,—a practice which, with Berzelius ("*Lehrbuch der Chemie,*" 1841, *4th Aufl.*, *p.* 516), he heartily commends, urging that it should be employed every time that a crucible is used,

—Erdmann explains the cause of the grey coating which forms upon platinum crucibles whenever they are ignited in the flame of Bunsen's gas-burner.

This coating has given rise to much annoyance and solicitude among chemists. Indeed, it has often been asserted that the use of Bunsen's burner is unadvisable in quantitative analysis, since, by means of it, the weight of platinum crucibles is altered, and the crucibles themselves injured. The coating is produced most rapidly when the crucible is placed in the inner cone of the flame, and the more readily in proportion as the pressure under which the gas is burned is higher. Having found it advantageous to maintain, by means of a special small gas-holder, a pressure of four or five inches upon the gas used in his own laboratory, Erdmann has observed that the strong gas flame thus afforded immediately occasions the formation of a dull ring upon the polished metal placed in the inner flame, this ring being especially conspicuous when the crucible becomes red hot; it increases continually, so that after long-continued ignition the whole of the bottom of the crucible will be found to be grey, and with its lustre dimmed.

This ring is caused neither by sulphur, as some have believed, nor by a coating of inorganic matter, but is simply a superficial loosening of the texture of the platinum in consequence of the strong heat; whence it first of all appears in the hottest part of the flame.

In conjunction with Pettenkofer, Erdmann instituted several experiments, which have left but little doubt that the phenomenon depends upon a molecular alteration of the surface of the metal. If a weighed polished crucible be ignited for a long time over Bunsen's lamp, the position of the crucible being changed from time to time in order that the greatest possible portion of its surface shall be covered with the grey coating, and its weight be then determined anew, it will be found that this has not increased. The coating cannot be removed either by melting with bisulphate of potash or with carbonate of soda. It disappears, however, when the metal is polished with sand; the loss of weight which the crucible undergoes being exceedingly insignificant, a crucible weighing 25 grammes having lost hardly half a milligramme. When the grey coating of the crucible is examined under the microscope, it may be clearly seen that the metal has acquired a rough, almost warty surface, which disappears when it is polished with sand. Platinum wires which are frequently ignited in the gas flame, —for example, the triangles which are used to support crucibles,— become, as is known, grey and brittle. Under the microscope, they exhibit a multitude of fine longitudinal cracks, which as the original superficial alteration penetrates deeper, become more open, or, as it were, spongy, until finally the wire breaks.

If such wire is strongly and perseveringly rubbed with sand, the cracks disappear, and the wire becomes smooth and polished; for the grains of sand, acting like burnishers, restore the original tenacity of the metal, very little of its substance being rubbed off meanwhile. The loosening effect of a strong heat upon metals is beautifully ex-

hibited when silver is ignited in the gas flame; a thick polished sheet of silver immediately becoming dull white when thus heated. Under the microscope, the metal appears swollen and warty. Where it has been exposed to the action of the inner flame along its circumference, this warty condition is visible to the naked eye. A stroke with the burnishing-stone, however, presses down the loosened particles and reproduces the original polish. This peculiar condition which the surface of silver assumes when it is ignited, is well known to silversmiths; it cannot be replaced by any etching with acids; and it must be remembered that what is dull white in silver appears grey in platinum.

If each commencement of this loosening is again destroyed, the crucibles will be preserved unaltered, otherwise they must gradually become brittle. Crucibles of the alloy of platinum and iridium are altered like those of platinum when they are ignited. It is, however, somewhat more difficult to reproduce the original polish of the metal by means of sand, as might be expected from the greater hardness of the alloy.

The sand used should be well worn. When examined under the microscope, no grain of it should exhibit sharp edges or corners; all the angles should be obtuse.—*Journ. fur praktische Chemie*, lxxix, 117.

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For the Journal of the Franklin Institute.

## *Triangular Beams.* By Prof. D. Wood.

As I find that the statements of different authors respecting the strength of triangular beams are very conflicting, I propose in this article to make an analytical investigation of the problem, and compare the results with experiment.

The problem may, for convenience, be thus stated:

*A triangular prism being supported at its extremities; it is required to ascertain how great a weight it will sustain at the middle point without fracture.*

But as we know that the strength of a beam depends upon its transverse sections, it will only be necessary to investigate the *resistance of a triangular section.*

To introduce the several points which I wish to discuss, I shall make extracts from various authors. I find in Olmstead's Natural Philosophy, p. 153 (or p. 107 of Prof. Snell's edition), the following statement:

"*A triangular beam is twice as strong when resting on its broad base as when resting on its edge.*

I would pass this statement with the remark that the deduction is founded on Galileo's theory, which is known to be false, were it not for the fact that many think that the statement is correct; also that beams made of some kinds of material are stronger in the former than in the latter position, but not for the reasons given by Olmstead.

1. Suppose the beam is made of wood.

The resistance of wood to compression is nearly the same as for ex-

tension. If it were the same, the beam would be equally strong in either position; for the same strain comes upon the edge, whether it be up or down.

But if it resist more to tension than compression it would be stronger *when resting on its edge*, and *vice versa*. These conclusions are fully sustained by experiment. Mr. Couch made some experiments on triangular (Canadian) oak beams, fixed by one end and loaded at the other. The mean of four experiments gave,

with the angle upward, . 315 lbs.
" downward, . 348 "

(See Barlow's Strength of Materials, p. 118.)

2. Suppose the beam is made of cast iron.

Cast iron will resist about 6 times as much to compression as to tension (see Mahan's Civil Engineering, p. 82). Hence, if we suppose the yielding to be at the angle, the beam will be six times as strong when the angle is upward as when it is downward. I know of no experiments on triangular cast iron beams, but Barlow has made experiments which confirm us in our conclusion (see his Strength of Materials, p. 337; also, Mahan, p. 88). In a similar manner we might determine the relative strength of a beam in the two positions if made of any other material. If the beam is fixed at one extremity instead of being supported, then the preceding conclusions would be reversed.

I now propose *to find the strongest trapezoidal beam which can be cut from a given triangular one.*

To investigate this case, we will resort to the fundamental expression for the resistance of beams subjected to a transverse strain.

Let $R$ = the ultimate resistance of a unit of section to compression or extension.

$d_{\prime}$ = distance of the farthest fibre from the neutral surface.

$I$ = moment of inertia of the section about an axis through its centre of gravity and parallel to the base.

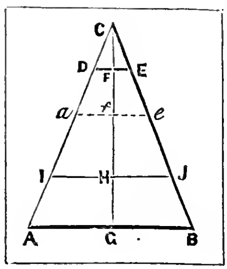
We then have for the moment of resistance

$$\frac{R\,I}{d_{\prime}}$$

[See Mosley's Mechanics and Engineering Eq., (637).]

Let $ABC$ be the given triangle.

$ABED$ the required trapezoid.




Let $b = AB$. $v = DE$.

$a = CG$ = longest altitude of $ABC$. $w = CF$.

$H$ = centre of gravity of the trapezoid $ABED$.

$d_{\prime} = FH$. (2) $z = CH = d_{\prime} + w$.

$IJ$ is the neutral axis of the trapezoid.

To find $CH$, we have, from the equation of moments, origin at $C$,

$$\tfrac{1}{2}\,a\,b\,\tfrac{2}{3}\,a = \tfrac{1}{2}\,v\,w\,\tfrac{2}{3}\,w + \frac{b+v}{2}\,(a-w)\,z.$$

$$(3) \qquad \therefore \qquad z = \tfrac{2}{3}\,\frac{a^2 b - v w^2}{(b+v)(a-w)}.$$

(4) From the similarity of triangles we have

$$v : w :: b : a \qquad \therefore \quad w = \frac{a}{b}\, v.$$

From (2) and (3) we have $d_{\prime} = z - w = \frac{2}{3}\,\frac{a^2 b - v w^2}{(b+v)\,(a-w)}\, w$;

by substituting $w$ from (4) we have

(5) $$d_{\prime} = \tfrac{1}{3}\,\frac{a}{b}\,\frac{2\,b^2 - b\,v - v^2}{b+v}.$$

The moment of inertia about I J as an axis is equal to the moment of inertia about D E *minus* the area A B E D $\times \overline{\text{F H}}^2$.

Let $\text{F}f = x$. $\qquad d\,e = y$.

Then from the similar triangles C D E and C $d\,e$ we have

$$y : b :: x + w \text{ or } x + \frac{a}{b}\, v : a.$$

$$\therefore \quad y = \frac{b\,x + a\,v}{a}.$$

Hence, the moment of inertia about D E as an axis is

$$\int_0^{x=a-w} x^2\, y\, d = \int_0^{\frac{a}{b}(b-v)} \frac{x^2}{a}\,(b\,x + a\,v)\, d\,x = \frac{b}{a}\left[\frac{x^4}{4}\right]_0^{\frac{a}{b}(b-v)} + \left[\frac{v}{3}x^3\right]_0^{\frac{a}{b}(b-v)}$$

(6) $$= \frac{a^3}{12\,b^3}\,(3\,b^4 - 8\,b^3 v + 6\,b^2 v^2 - v^4).$$

Area of the trapezoid is

$$\frac{b + w}{2}\,(a - v) = \frac{a}{2\,b}\,(b^2 - w^2),$$

which multiplied by $\overline{\text{F H}}^2 = d_{\prime}^{\,2}$ gives

(7) $$\frac{1}{18}\,\frac{a^3}{b^3}\,(b^2 - v^2)\left(\frac{2\,b^2 - b\,v - v^2}{b+v}\right)^2;$$

which subtracted from (6) gives the moment of inertia about I J; which by reduction will become

$$\text{I} = \frac{1}{36}\,\frac{a^3}{b^3}\left[b^4 - v^2(8\,b^2 - 16\,b\,v + 9\,v^2) - 8\,\frac{b-v}{b+v}\,v^4\right]$$

(8) $$= \frac{1}{36}\,\frac{a^3}{b^3}\left[\frac{b^5 + b^4 v - 8\,b^3 v^2 + 8\,b^2 v^3 - b\,v^4 - v^5}{b+v}\right].$$

If $v = 0$ this becomes $= \frac{1}{36}\,a^3\,b$, which is the moment of inertia of a triangle about one axis passing through its centre of gravity and parallel to its base.

By substituting (5) and (8) in (1) we have

(9) $$\text{R}\,\frac{\text{I}}{d} = \frac{1}{12}\,\text{R}\,\frac{a^3}{b^3}\left[\frac{b^5 + b^4 v - 8\,b^3 v^2 + 8\,b^2 v^3 - b\,v^4 - v^5}{2\,b^2 - b\,v - v^2}\right]$$

which is to be a maximum;

∴ we have

(10) $\frac{du}{dv} = 0 = v^6 + 2bv^5 - 5b^2v^4 - 8b^3v^3 + 19b^4v^2 - 10b^5v + b^6.$

By discussing this equation we find that it has three roots, each equal $b$, which gives a minimum. Divide Eq. (10) by $(v - b)^3$, and we have

(11) $$v^3 + 5bv^2 + 7b^2v - b^3 = 0$$

(12) make $v = \frac{z - 5b}{3}$ and (11) becomes

$$x^3 - 12b^2z - 92b^3 = 0,$$

which solved by Cardan's formula gives

$z = 5{\cdot}39118\,b,$ and this in (12) gives

(13) $v = 0{\cdot}13093\,b,$ and this in (4) gives

(14) $w = 0{\cdot}13093\,a.$

By substituting $v$, Eq. (13), in (9) it becomes

(15) $$\text{R}\frac{\text{I}}{d} = 0{\cdot}545625\,\frac{\text{R}\,a^2b}{12}.$$

Making $v = 0$ in (9), we have the moment of the full triangular

(16) section $= 0{\cdot}5\,\frac{\text{R}\,a^2b}{12}.$

Taking Eq. (16) from (15) we have

$$0{\cdot}04562\,\frac{\text{R}\,a^2b}{12}.$$

Hence, *if the angle of the prism be taken off to* ·13 *of its depth, the prism will be* $0{\cdot}04562\,\frac{\text{R}\,a^2b}{12}$ *stronger*, or 1·09125 *times as strong, which is a gain of over* 9 *per cent.*

Haupt, in his valuable work on Bridge construction, p. 51, says: "It is found that the prism becomes one-thirty-seventh part stronger when the angle is taken off to one-tenth of the depth."

By making $v = {\cdot}1$ in (9) it becomes

(17) $$0{\cdot}54385\,\frac{\text{R}\,a^2b}{12},$$

which is $0{\cdot}04385\,\frac{\text{R}\,a^2b}{12}$ stronger than the full section. Dividing this by (16) we find that it is 0·0877, or more than one-twelfth part stronger.

Barlow, in his Strength of Materials, p. 116, intimates "that it is the commonly received notion, that if the vertex, or upper edge of a triangular prismatic beam, be cut off to one-third the depth, the piece will be stronger than before."

To compare this "received notion" with theory, make $v = \frac{1}{3}$ in (9), and we have

(18) $$0{\cdot}465608\,\frac{\text{R}\,a^2b}{12},$$

which being divided by (16) gives 0·93101, or according to theory

*this trapezoid beam should be only ninety-three-hundredths as strong as the triangular one from which it is cut.*

This conclusion is sustained to a remarkable degree of exactness by the experiments of Mr. Couch as given by Barlow, p. 118.

The mean of seven experiments made by Mr. Couch on the strength of triangular oak beams with the angle upward, is 306 lbs.

The mean of two on trapezoidal beams with the narrow side up, made from triangular prisms of the same size used in the preceding experiments by cutting off the angle to one-third the depth, is 284·5 lbs., which is only four-hundredths lb. less than ·93 of 306 lbs.

By comparing expressions (15), (16), (17), and (18), and calling the strength of the triangular beam unity, we have the following results:

| | |
|---|---|
| Strength of the triangular beam, | 1. |
| Strength of the same beam if the edge be cut off to $\frac{1}{3}$ the depth, | 0·93101 |
| " " " " 1-10 " | 1·0877 |
| " " " " so as to give a maximum strength, | 1·0912 |

In order to explain this apparent paradox, we must remember that the condition is not that the triangular beam shall be fractured completely through, but that it shall not be fractured at all. Now the *greatest strain* comes upon the edge, but there is only one fibre there to resist it; but after a small portion of the edge is removed there are many fibres along the line D E at the same distance from the neutral surface, each of which will sustain the same part of the *greatest strain.*

If the triangular beam were loaded so as to just commence fracturing at the edge, we might increase the load 9 per cent. and increase the fracture to only thirteen-hundredths of its depth; but if the load be increased beyond this amount, it will break the beam completely in two.

Again, Haupt says (p. 51), "It is found that the strength of the triangular prism is to that of a rectangular prism having the same base and altitude, as 339 : 1000, or nearly as 1 : 3."

The moment of resistance of the triangular section is, Eq. (16),

$$\frac{1}{24}\,\text{R}\,a^2 d.$$

The moment of resistance of a rectangular section is well known to be (found from (1)), $\frac{1}{6}\,\text{R}\,a^2 d.$

Hence, theoretically, they are to each other as 1 : 4.

I will close this article by comparing the maximum trapezoidal beam with a rectangular one having the same base and altitude.

Let $d$ = altitude = 0·87 $a$, nearly;

$$\therefore \qquad a^2 = \frac{d^2}{\cdot 7569},$$

which substituted in (15) gives

$$0{\cdot}72\,\frac{\text{R}\,d^2 b}{12}.$$

Hence the resistance of the maximum trapezoidal beam is that of a rectangular one having the same base and altitude as $\frac{1}{12}$ of 0·72 : $\frac{1}{6}$, or as 360 : 1000.

*Experiments made by M. Starke, with the machine of the Polytechnic Institution of Vienna, upon various Cast Steels made at the Imperial and Royal Foundry at Reichraming in Styria.*

| | Breaking weight per square millimetre. | |
|---|---|---|
| No. 1. Common Steel of Reichraming, | 92·49 kilog. | |
| " " | 83·29 | |
| " " | 85·39 | |
| 2 " | 51 89 | Defect in the fracture. |
| " " | 81·91 | |
| " " | 96·84 | |
| 3 " | 112·42 | |
| " " | 105 32 | |
| " " | 86·44 | |
| 4. English Steel, (known as Huntsman's,) | 84·34 | |
| " " | 86·51 | |
| " " | 76·99 | Blister in surface of rupture. |
| 5. Steel made with Tungsten, | 102·26 | |
| " " | 109 27 | |
| " " | 117·10 | Broke at a section greater than the minimum. |

Note.—The kilogramme = 2·2 lbs. The millimetre = 0·0394 inch.

*Bull. Soc. Encour. Indust. Nat.*, May, 1860.

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## *Superheated Steam.*

The readers of the *Journal* have no doubt read much on this subject in the last few years, and there can be no doubt that, if superheated steam is properly used, a saving of fuel may be effected. Many of the statements published, however, have made the success too great. It will be remembered that, a short time since, the *Artizan* published some very flattering accounts of the performance of the English Pacific Mail steamers, whose machinery was put in by Randolph, Elder & Co. The engines had double cylinders, and used *highly superheated steam* (450 to 500 degrees). It is now found that this high heat is very destructive to the engines, injuring the cylinders, pistons, valve faces, and valves. So great has the injury been, that they have commenced to take out and much reduce the number of superheating tubes. B.

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## *Artificial Making of Ice.*

M. Carré takes two iron retorts strong enough to bear a pressure of 8 atmospheres; two mercury-bottles for instance. In one he places a very concentrated solution of ammonia; and then connects it by a tube with the other retort which is empty. A furnace heats the first retort, the second is buried in a vessel containing water at the temperature of

the air. The heat disengages the ammonia from its solution, and it passes over into the cool retort, where the pressure due to its accumulation gradually condenses it into a liquid. The furnace is then withdrawn from the other retort, which is suffered to cool, and as soon as it has cooled sufficiently, the pressure is reduced within it, and at a certain point the ammonia passes abruptly into a gas again, absorbing from the water which surrounds the retort the heat necessary for its evaporation. A part of the water is frozen, and $2\frac{1}{2}$ kilog. (5 lbs.) of ice may thus be obtained. Of course, the operation may be repeated at pleasure. The apparatus, as will be seen, is excessively simple, and is said to be marvellously effective. It is affirmed that the price of ice thus obtained will not exceed 1 centime per kilogramme ($\frac{1}{10}$th of a cent) per lb.—*Cosmos,* December, 1860.

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### *Electric Light. A Beautiful Experiment.*

On the 2d of September a first experiment was made, of illuminating the famous Falls of Schaffhausen on the Rhine, 30 yards in height, by means of five electric lights: the effect is said to have been marvellous; especially when viewed through colored glasses; the waves of the river resembled a sea of fire. It is said that the experiment was instituted at the request of the directors of the Swiss Railroad Company, who propose during the coming year to organize a series of night-fêtes, of which this illumination will be the greatest attraction.

*Cosmos,* September, 1860.

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### *Fire Extinguished by Steam.*

A fire took place on the 22d of November, in the cellars of a candle manufacturer, situated on the *Route d'Italie,* outside the barrier. The engines were of but little value, and to subdue the flames they had recourse to a mode but little in use. The cellar-doors and windows having been hermetically shut, steam was introduced and the fire in a few moments extinguished. By this quick and effectual method, 200 tons of oil which the flames were on the point of reaching were preserved.

*Cosmos,* November, 1860.

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## AMERICAN PATENTS.

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AMERICAN PATENTS ISSUED FROM DECEMBER 1, TO DECEMBER 31, 1860.

| | | | | |
|---|---|---|---|---|
| Ash Sifters, | Seth Wheeler, | Albany, | N. Y. | 18 |
| Bag Holder and Conveyer, | C. K. Hostetter, | E. Donegal, | Penna. | 18 |
| Bags,—Machinery for Turning | W. V. Gee, | New Haven, | Conn. | 4 |
| Barrels,—Finishing the Inside of | Edmund Greenlee, | Summer Hill, | Penna. | 4 |
| Bedstead,—Folding | G. D. Sargent, | Boston, | Mass. | 11 |

| | | | | |
|---|---|---|---|---|
| Bee Hives, . | I. C. Pratt, . | Morton, | Ill. | 18 |
| Blasting Rocks,—Mode of | John Gilleland, . | Athens, | Ga. | 4 |
| Boilers, . | Cornelius Godfrey, | Brooklyn, | N. Y. | 18 |
| Bolt Cutter, . | J. K. Taylor, . | Bridgeport, | Conn. | 11 |
| Boots and Shoes,—Pegging | F. J. Vittum, . | Chelsea, | Mass. | 4 |
| Boot-jack, . | John Durham, . | Cherry Grove, | Ohio, | 18 |
| Brakes,—Car . | Peter Keffer, . | Reading, | Penna. | 18 |
| ———,—Railroad Car . | R. W. Hix, . | City of | N. Y. | 18 |
| Buttonholes,—Cutting | F. C. Leypoldt, . | Philadelphia, | Penna. | 18 |
| Butt Hinge, . | Jasper Johnson, . | Genesee, | N. Y. | 18 |
| Cane Juice,—Purification of | Jean Communy, | New Orleans, | La. | 11 |
| Caoutchouc,—Vulcanizing | Falke & Richard, . | College Point, | N. Y. | 4 |
| Carding Engines, . | James Fitton, . | Cavendish, | Vt. | 11 |
| Carriage Wheels, . | J. P. Fisher, . | Rochester, | N. Y. | 18 |
| Chain, . | John Blocher, . | Williamsville, | " | 4 |
| Chair,—Folding . | H. T. Pratt, . | Fitchburg, | Mass. | 4 |
| ——,—Recumbent | P. J. Hardy, . | City of | N. Y. | 11 |
| Churn, . | John Pike, . | Syracuse, | " | 18 |
| ——— . | D. T. Ward, . | Mansfield, | Ohio, | 18 |
| Cigars,—Making . | Ferdinand Wuterich, | City of | N. Y. | 18 |
| Cloth,—Stretching | E. C. Cleveland, | Worcester, | Mass. | 11 |
| Clothes Drier, . | H. C. Boardman, . | Morrisville, | Vt. | 11 |
| ——— Wringer, . | G. J. Colby, . | Waterbury, | " | 4 |
| Clover,—Hulling . | J. D. Forrey, . | Lewiston, | Penna. | 18 |
| ————— . | Noraconk & Hoats, | Milton, | " | 18 |
| Coal Sifters, . | G. W. Pittock, . | Union Mills, | N. Y. | 18 |
| Coffins,—Glass . | G. B. Field, . | St. Louis, | Mo. | 11 |
| Collimators, . | Fairchild & Joyce, . | City of | N. Y. | 11 |
| Comb Cleaner, . | C. P. S. Wardwell, | Lake Village, | N. H. | 18 |
| Copying Presses, . | Elisha Clark, . | City of | N. Y. | 18 |
| Cord,—Covering . | Heinemann & Buser, | " | " | 18 |
| Corn Planters, . | S. W. Adams, . | Moultrie co., | Ill. | 11 |
| ———— . | W. R. Center, . | Athens, | " | 4 |
| ———— . | A. S. and D. Markham, | Monmouth, | " | 11 |
| ———— . | Mowry & Deppen, | Womelsdorf, | Penna. | 11 |
| ———— . | J. H. Rankin, . | Versailles, | Mo. | 4 |
| ——,—Husking and Shelling | John Wind. . | Thomasville, | Ga. | 4 |
| Cotton Cleaners, . | J. Ryder and others, . | Clinton, | La. | 18 |
| ——— Cleaning Machines, | Benjamin Jackson, | Louisville, | Ky. | 11 |
| Coupling for Hose Pipe, . | Button & Blake, . | Waterford, | N. Y. | 18 |
| Cultivators, . | H. M Belden, . | Farmington, | Ohio, | 4 |
| ———— . | Geisinger & Williams, | Montville, | " | 18 |
| ———— . | Jos. and St. Clair Gum, | Marseilles, | Ill. | 18 |
| ———— . | Isaac Miers. . | Clay Lick, | Ohio, | 18 |
| ———— . | Benjamin Tinkham, | Cameron, | Ill. | 11 |
| ————,—Cotton, . | N. A. H. Goddin, . | Wilson, | N. C. | 4 |
| ————,—Seeding | T. A. Galt, . | Sterling, | Ill. | 11 |
| Curtain Cords, . | T. L. Pye, . | City of | N. Y. | 18 |
| ——— Fixture, . | Harold & Kelty, | Brooklyn, | " | 11 |
| Dentists Crystalline Gold, | A. J. Watts, . | Utica, | " | 4 |
| Dumb Waiters, . | Andrew Murtaugh, | City of | " | 4 |
| Eave Troughs, . | G. M. Selden, . | Troy, | " | 8 |
| Ellipsograph, . | R. E. Harte, . | Marietta, | Ohio, | 4 |
| Envelopes, . | J. B. Murray, . | City of | N. Y. | 18 |
| Excavators, . | J. P. Hayes, . | Hennepin, | Ill. | 4 |
| Extension Table, . | George Hunzinger, . | Brooklyn, | N. Y. | 4 |
| Faucets for Bottles, | Jacob Hiney, . | Hartford, | Conn. | 18 |
| Feed Cutters, . | G. W. Hathaway, . | Tioga, | Penna. | 4 |
| Fertilizers,—Sowing | B. Picquet, . | Augusta, | Ga. | 11 |

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|---|---|---|---|---|
| Fire Escapes, . | Claude Sturel, . | City of | N. Y. | 18 |
| Fluid,—Expanding, &c., Elastic | John Jameson, . | Gateshead, | Engl'd, | 18 |
| Foot-scraper and Brush, . | Henry Warren, . | Hoboken, | N. J. | 4 |
| Gas and Water Pipe,—Tapping | J. J. Watson, . | Buffalo, | N. Y. | 11 |
| —— Burner Regulator, . | Wm. Mallerd, . | Bridgeport, | Conn. | 18 |
| Glass Cutters, . | Moses Kleeman, | Columbus, | Ohio, | 18 |
| Gongs,—Striking Mechanism for | S. S. Chandler, . | Chelsea, | Mass. | 4 |
| Grain,—Cleaning . | R. C. Mauck, . | Harrisonburg, | Va. | 18 |
| —— Riddles, . | Anson Rowe, . | Atallissa, | Iowa, | 4 |
| —— Separators, . | F. W. Robinson, | Richmond, | Ind. | 18 |
| Hame Tugs,—Fastening for | J. W. Church, . | Cold Water, | Mich. | 18 |
| Harness Trace, . | Edmund Maher, | City of | N. Y. | 4 |
| Harpoons,—Explosive . | Theodore Briggs, . | Philadelphia, | Penna. | 11 |
| Harrows, . | John Allen, . | Union, | N. Y. | 18 |
| ——,—Rotary . | M. L. Bauder, . | Cleveland, | Ohio, | 4 |
| Harvesters, . | John Blue, . | Covert, | N. Y. | 18 |
| ——,—Cotton . | Apperly & Johnson, . | Memphis, | Tenn. | 11 |
| ——,—Rakes for | S. A. Lindsay, . | Unionville, | Md. | 11 |
| —— . | Adam Pritz, . | Dayton, | Ohio, | 4 |
| Harvesting Machines, | McClintock Young, Jr., | Frederick, | Md. | 18 |
| —— . | J. S. Royce, . | Cuylerville, | N. Y. | 18 |
| ——,—Rakes for | L. P. Brady, . | Mount Joy, | Penna. | 18 |
| Hats,—Shaping . | S. H. Apple and others, | City of | N. Y. | 4 |
| Hogs from Rooting,—Preventing | D. K. Nixon, . | Sandyville, | Ohio, | 18 |
| Horse Collars, . | John Ende, . | Buffalo, | N. Y. | 18 |
| Horses from Carriages,—Detach. | Solomon Kepner, | N. Coventry, | Penna. | 18 |
| Hydraulic Engines, : | Thomas & Hall, . | Beverly, | Va. | 4 |
| Insect Shields for the Head, | John Haven, . | Boston, | Mass. | 4 |
| Lamp Chimneys,—Securing | J. J. Marcy, . | Meriden, | Conn. | 4 |
| Lamps,—Vapor . | J. S. Gray, . | City of | N. Y. | 18 |
| —— . | F. W. Willard, . | " | " | 11 |
| Lathe Dog,—Automatic | A. E. Wenzel, . | " | " | 18 |
| Lock,—Combination . | J. H. Morse, . | Peoria, | Ill. | 4 |
| ——,—Knob . | John Adt, . | Waterbury, | Conn. | 11 |
| Loco. Engines,—Exhaust Pipes | G. W. Lathrop, . | Weedsport, | N. Y. | 18 |
| ——,—Superheat. st'm | James Martin, . | Toronto, | Can. | 4 |
| ——,—Supply. Water | Merritt & Kemplen, . | Woodstock, | Ill. | 4 |
| Looms, . | Andrew Parkinson, | Norwich, | Conn. | 18 |
| Mangle, . | Wm. D. Grimshaw, . | City of | N. Y. | 4 |
| Mattress,—Life-preserving | Louis Bauhoefer, | Philadelphia, | Penna. | 4 |
| Medicated Lotions, . | J. G. Popp, . | Vienna, | Austria, | 4 |
| Millstones,—Dressing | B. D. Tripp, . | Moravia, | N. Y. | 18 |
| Mouldings,—Enameling . | Gabriel Boos, . | City of | " | 18 |
| Mowing Machines, | J. G. Dunham, . | Raritan, | N. J. | 18 |
| Musical Instruments, . | E. D. Bootman, . | Janesville, | Wis. | 18 |
| Oiling Spindles, . | E. N. Steere, . | Providence, | R. I. | 18 |
| Paddle Wheel,—Feathering | Byron Densmore, . | Brockport, | N. Y. | 4 |
| Padlock, . | John North, . | Middletown, | Conn. | 18 |
| Paper,—Folding . | J. S. Gallaher, Jr., . | Washington, | D. C. | 4 |
| —— Folding Machines, | Cyrus Chambers, Jr., | Philadelphia, | Penna. | 18 |
| Parchment,—Vegetable . | Xavier Karcheski, . | City of | N. Y. | 18 |
| Peach Parer and Cutter, | H. St. J. Hilsman, | Madison, | Ga. | 4 |
| Pendulum,—Compensating | George Buchanan, . | Hickory, | Penna. | 4 |
| Pegging Machines, | Parker Wells, . | Middleton, | Mass. | 18 |
| Pens,—Fountain . | Ebenezer Mathers, . | Fairmount, | Va. | 4 |
| —— . | S. A. Skinner, . | W. Berkshire, | Vt. | 18 |
| —— . | G. W. Woolley, . | Philadelphia, | Penna. | 4 |

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|---|---|---|---|---|
| Photographic Cameras, | Simon Wing, . | Waterville, | Me. | 4 |
| Planers,—Parts in Rotary | A. J. Kramer, . | Marion, | Iowa, | 11 |
| Planing Machines,—Wood | H. D. Stover, . | City of | N. Y. | 18 |
| Plough Clevises, . | J. S. Hall, . | Manchester, | Penna. | 4 |
| Ploughs, . | H. H. Baker, . | New Market, | N. J. | 11 |
| ——— . | Everett Bass, . | Pachitta, | Ga. | 4 |
| ——— . | J. G. Robinson, . | Biddeford, | Me. | 4 |
| ——— . | Oliver Sparks, . | Shelbina, | Mo. | 11 |
| ——— . | Smithwick Whitley, . | Tallahassee, | Fla. | 4 |
| ———,—Gang . | Jacob Haege, . | Shiloh, | Ill. | 18 |
| ———,—Steam | Wm. H. H. Meillen, | Littleton, | N. H. | 11 |
| ——————— . | John Reynolds, . | City of | N. Y. | 18 |
| Pressure Gauge, . | C. M. Daboll, . | New London, | Conn. | 4 |
| Pumps, . | J. B. Johnson, . | Boston, | Mass. | 4 |
| Quartz Rock, &c.,—Breaking | S. F. Hodge, . | Detroit, | Mich. | 4 |
| ———,—Mills for Crushing | " . | " | " | 4 |
| Railroad Car Frames, . | T. L. Nickols, . | Alexandria, | Va. | 4 |
| ——— Cars,—City | Grice & Long, . | City of | N. Y. | 18 |
| ——————,—Warming | J. J. Watson and others, | Buffalo, | " | 18 |
| ——— Cross Ties, . | R. C. Bailey, . | Greensboro, | N. C. | 4 |
| ——— Switches, | Horace Tupper, . | Buffalo, | N. Y. | 4 |
| ———,—Turn-outs for Street | " . | " | " | 18 |
| Railway Signals, . | P. F. Milligan, . | Baltimore, | Md. | 18 |
| Rakes for Reaping Machines, | J. R. Byler, . | Salisbury t'p, | Penna. | 4 |
| Revolvers, . | Smith & Wesson, . | Springfield, | Mass. | 18 |
| ——— . | Eben F. Starr, . | City of | N. Y. | 4 |
| Roofing.—Cement for . | J. F. Hammond, . | Lynn, | Mass. | 18 |
| Rotary Engine, . | J. J. Slocum, . | City of | N. Y. | 18 |
| Rovings,—Winding Woolen | J. A. Chapman, . | Pequetanuck, | Conn. | 18 |
| Saw Gauge,—Circular | Lysander Wright, | Newark, | N. J. | 18 |
| Sawing Machines,—Cross-cut | S. A. Worthen, . | Morrisville, | Vt. | 11 |
| ——————— | D. B. Bartholomew, | Lancaster, | Penna. | 11 |
| Saws,—Handles to . | E. C. Atkins, . | Indianapolis, | Ind. | 18 |
| Scales,—Platform . | Jedediah Holcomb, | Brandon, | Vt. | 18 |
| Seeding Machines, . | D. and W. W. Beal, . | Lester, | Iowa, | 11 |
| ——————— | Henry Bell, . | Clinton, | Ill. | 11 |
| ——————— . | Horace Crofoot, . | Tawboro, | N. C. | 11 |
| ——————— | Naylor & Ward, | Niles towns'p, | Ind. | 4 |
| ——————— . | J. V. H. Secor, . | City of | N. Y. | 11 |
| Seed Planters,—Cotton | R. C. Mash, . | Somerville, | Tenn. | 18 |
| ———————— . | C. A. Rose, . | Columbia, | Ala. | 4 |
| Sewing Machines, | J. W. Hardie, . | City of | N. Y. | 4 |
| ——— Needles, . | Henry Essex, . | Haverstraw, | " | 18 |
| Shirred Goods,—Making | Richard Solis, . | N. Brunswick, | N. J. | 11 |
| Shirt Bosom Expanders, . | S. J. Shaw, . | Marlborough, | Mass. | 4 |
| —— Studs, . | C. E. Haskins, . | Providence, | R. I. | 18 |
| Shoe Tacks, . | J. H. Knight, . | Newburyport, | Mass. | 18 |
| Shutter Operator, . | John Solan, . | Fredericksburg, | Va. | 18 |
| Skirts,—Clasp for Hooped | G. P. Evans, . | Malden, | Mass. | 11 |
| ——,—Skeleton . | E. G. Atwood, . | Derby, | Conn. | 18 |
| ——,—Spiral Hoop . | D. G. Rollin, . | City of | N. Y. | 4 |
| Smut Machines, . | Robert Thompson, | E. Davenport, | Iowa, | 18 |
| Spinning Frames,—Cylinders for | Robert Plews, . | Smithfield, | R. I. | 18 |
| Steam Boiler, . | B. F. Campbell, | Roxbury, | Mass. | 18 |
| ————— . | Samuel Solliday, . | Sumneytown, | Penna. | 18 |
| Stove Covers, . | John Russell, . | Troy, | N. Y. | 18 |
| —— Pipes, . | Levi Bissell, . | North Bergen, | " | 18 |
| Stoves,—Gas . | J. L. Mahan, . | Philadelphia, | Penna. | 18 |
| Straw,—Cutting . | Warren Gale, . | Chicopee Falls, | Mass. | 18 |
| Sugar,—Tanks for Crystallizing | C. E. Bertrand, . | City of | N. Y. | 18 |

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|---|---|---|---|---|
| Sugar-cane Leaf Stripper, | P. P. Mills, . | Washington, | Ohio, | 18 |
| Swifts, . | Newton Benedict, | Aurelius, | N. Y. | 11 |
| Temples, . | J. C. Tilton, . | Sanbornton Br. | N. H. | 11 |
| Tenoning Tool, . | Oswald Schevenell, | Marion, | Ala. | 11 |
| Thread,—Dressing . | Conant & Ives, . | Willimantic, | Conn. | 4 |
| ———— | O. and G Hall, . | Willington, | " | 4 |
| Time Registers, . | Robert Schone, . | City of | N. Y. | 4 |
| Tin Cans,—Wiring | Thomas Evans, . | Watkins, | " | 4 |
| Tobacco Cutters, . | W. H. Pease, . | Dayton, | Ohio, | 18 |
| Tuyere, . | C. H. Edwards, . | Vergennes, | Vt. | 4 |
| Valve Gear for Steam Engines, | J. R. Jacob, . | Elizabethtown, | Ky. | 18 |
| Valves, . | John and C. B. Hardick, | Brooklyn, | N. Y. | 4 |
| ——— for Oscillating Engines, | L. W. Langdon, . | Northampton, | Mass. | 4 |
| ——— of Boilers,—Safety | Charles Graham, | Scranton, | Penna. | 18 |
| ——— of St'm Eng's,—Operat'g | L. H. Bowman, . | Norristown, | Penna. | 18 |
| ———,—Slide . | Thomas Mahoney, | Knoxville, | Tenn. | 4 |
| Ventilating Buildings,—Means | S. M. Stone, . | New Haven, | Conn. | 18 |
| Wagons,—Road . | J. W. Lawrence, | City of | N. Y. | 11 |
| Washing Machine, . | D. P. Shope, . | Milesburg, | Penna. | 18 |
| ———— | P. D. Van Hoesen, | City of | N. Y. | 11 |
| Watch Ribbons,—Slides for | A. H. Hews, . | Cambridgeport, | Mass. | 18 |
| Watches,—Regulating | A. L. Dennison, | Waltham, | " | 11 |
| Water Drawers, . | A. A. Hotchkiss, . | Monroe City, | Mo. | 11 |
| ——— Elevators, . | Taylor & Larned, | Cleveland, | Ohio, | 11 |
| ———— & Conveyors, | J. F. Keller, . | Greencastle, | Penna. | 11 |
| ———,—Elevating | Luther Wentworth, | Burlington, | Iowa, | 4 |
| ———— . | J. D. Squires, . | Cold Spring, | N. Y. | 11 |
| ——— Wheels, . | Jud Crissey, . | Chatfield, | Minn. | 18 |
| ———— . | E. F. M. Fletcher, . | Georgia Plains, | Vt. | 18 |
| ———— . | Nelson Johnson, | Jasper, | N. Y. | 18 |
| Wrench, . | F. W. Kroeber, . | Forbestown, | Cal. | 18 |
| ——— . | Ezra Ripley, . | Troy, | N. Y. | 18 |

ADDITIONAL IMPROVEMENTS.

| | | | | |
|---|---|---|---|---|
| Coupling for Thills to Axles, | James Saddler, . | Egremont, | Mass. | 18 |
| Fabrics Incorrodible,—Render'g | T. G. Chase, . | Philadelphia, | Penna. | 11 |
| Insects,—Prevent. Depredations | F. G. Johnson, . | Brooklyn, | N. Y. | 18 |
| Refrigerators, . | Wm. Sims, . | City of | " | 4 |
| Washing Machine, . | Asbury Wilkinson, . | Shelbyville, | Ind. | 4 |

RE-ISSUES.

| | | | | |
|---|---|---|---|---|
| Bedsteads,—Folding (2 pat's) | J. B. Wickersham, | Brooklyn, | N. Y. | 18 |
| Copying Apparatus,—Portable | Wm. Van Anden, . | Poughkeepsie, | " | 18 |
| Corn Shellers, . | J. J. Johnston, . | Allegheny City, | Penna. | 11 |
| Harvesters,—Raking Attachment | W. H. Seymour & others, | Brockport, | N. Y. | 18 |
| Hat Bodies, (2 pat's) | H. A. Burr, . | City of | " | 4 |
| Irregular Forms,—Cutting | R. J. Mearcher, . | " | " | 18 |
| Paper Pulp,—Grinding | J. Jordan, Jr., and others, | Hartford, | Conn. | 4 |
| Preserve Cans, . | Carlton Newman, . | Birmingham, | Penna. | 18 |
| Projectiles, . | C. T. James, . | Providence, | R. I. | 11 |
| Provisions,—Curing . | D. E. Somes, . | Biddeford, | Me. | 11 |
| Rubber,—Hard . | T. J. Mayall, . | Roxbury, | Mass. | 11 |
| Seed Planters, (5 pat's) | G. W. Brown, . | Galesburg, | Ill. | 11 |
| Steering Apparatuses, | Jesse Reed, . | Marshfield, | Mass. | 4 |
| Threshing Machines, . | Spencer Moore, . | Central Bridge, | N. Y. | 18 |

DESIGNS.

| | | | | |
|---|---|---|---|---|
| Carpet (7 cases), . | E. J. Ney, . | Lowell, | Mass. | 18 |
| Floor Cloths, . | C. T. Meyer, . | Boston, | " | 4 |

| | | | | |
|---|---|---|---|---|
| Iron Shutters, . | E. H. Brown, . | City of | N. Y. | 18 |
| Stove, . | Zebulon Hunt, . | Hudson, | " | 4 |
| —— . | Smith & Brown, | Philadelphia, | Penna. | 18 |
| Stoves, . | Isaac DeZouche, . | St. Louis, | Mo. | 4 |
| ———,—Cooking | Jacob Steffe. . | Philadelphia, | Penna. | 18 |
| ———————— . | C. J. Woolson, . | Cleveland, | Ohio, | 4 |
| Stove Plates, . | Vedder & Ripley, | Troy, | N. Y. | 18 |
| ———— . | Vedder & Sanderson, | " | " | 18 |
| ———— . | C. J. Woolson, . | Cleveland, | Ohio, | 4 |

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## FRANKLIN INSTITUTE.

### *Proceedings of the Stated Monthly Meeting, February* 21, 1861.

John C. Cresson, President, in the chair.

John Agnew, Vice President.

Isaac B. Garrigues, Recording Secretary.

The minutes of the last meeting were read and approved.

A letter was read from the Board of Arts and Manufactures, Montreal, Canada, transmitting a catalogue of their Exhibition held last Autumn, and a Bronze Medal struck on the opening of the Victoria Bridge by H. R. H. Prince of Wales, Montreal, 1860.

Donations to the Library were received from the Royal Society, the Royal Astronomical Society, the Statistical Society, and the Society of Arts, London; la Société Industrielle de Mulhouse, France; the Oesterreischischen Gewerbe-Veriens, the Oesterreischischen Ingenieurs-Veriens, Vienna, Austria; the Board of Arts and Manufactures and Capt. L. A. Huguet-Latour, Montreal, Canada; the Board of Trade, Detroit, Michigan; the Ohio Mechanics Institute, Cincinnati, Ohio; E. S. Philbrich, Esq., Boston, Mass.; the American Institute, City of New York; the Commissioner of Patents, Washington City, D. C.; W. R. DeWitt, State Librarian, H. G. Leisenring, Esq., and John Heisely, Esq., Harrisburgh, Penna; Wm. Linn Brown, Esq., the Pennsylvania Institution for the Blind, the American Philosophical Society, the North Pennsylvania Railroad Co., the Mine Hill and Schuylkill Haven Railroad Co., Prof. John C. Cresson, and George M. Conarroe, Esq., Philadelphia.

The Periodicals received in exchange for the Journal of the Institute, were laid on the table.

The Treasurer's statement of the receipts and payments for the month of January was read.

The Board of Managers and Standing Committees reported their minutes.

Candidates for membership in the Institute (4) were proposed, and the candidates proposed at the last meeting (5) duly elected.

The Board of Managers reported that they had organized for the present year by electing Mr. James H. Bryson, Chairman, and Messrs.

Isaac S. Williams and John M. Gries, Curators, and have appointed the following Standing Committees:

| *On Publications.* | *On Instruction.* | *Managers Sinking Fund and Finance.* |
|---|---|---|
| John C. Cresson, | John F. Frazer, | Frederick Fraley, |
| B. H. Bartol, | Frederick Fraley, | Samuel V. Merrick, |
| J. Vaughan Merrick, | Isaac B. Garrigues, | Evans Rogers, |
| Fairman Rogers, | Alan Wood, | John F. Frazer, |
| Washington Jones. | George Erety. | George Erety. |

The Standing Committees for the ensuing year were appointed by the President, and approved as follows:

| *On the Library.* | *On Cabinet of Models.* | *On Cabinet of Minerals.* |
|---|---|---|
| John Allen, | James Agnew, | Isaac H. Conrad, |
| Henry Ames, | Joseph Alexander, | Wm. T. W. Dickeson, |
| James H. Cresson, | William B. Bement, | John F. Frazer, |
| George M. Conarroe, | James Fraiser, | Emile Geyelin, |
| George Erety, | George W. Hubbard, | Isaac B. Garrigues, |
| John Ferguson, | Henry W. Hook, | John L. LeConte, |
| Raper Hoskins, | John L. Perkins, | B. Howard Rand, |
| James T. Lukens, | Coleman Sellers, | Robert E. Rogers, |
| Samuel Middleton, | John A. Scot, | Percival Roberts, |
| John S. Sleep. | Henry J. White. | John C. Trautwine. |

| *On Cab. of Arts & Manuf.* | *On Exhibitions.* | *On Meetings.* |
|---|---|---|
| Daniel Allen, | John E. Addicks, | William B. Atkinson, |
| James C. Booth, | John Agnew, | Robert Briggs, |
| Thomas Bickerton, | James H. Bryson, | William H. Brown, |
| Henry Bower, | James H. Cresson, | Charles S. Close, |
| John H. Burgin, | William A. Drown, | James Dougherty, |
| Robert C. Cornelius, | John M. Gries, | Thomas M. Drysdale, |
| Charles G. Crane, | Edwin Greble, | Henry Howson, |
| David M. Hogan, | William Harris, | Washington Jones, |
| Henry J. Taylor, | Thomas S. Stewart, | B. Howard Rand, |
| Henry P. Taylor. | Isaac S. Williams. | John E. Wootten. |

*On Meteorology.*

| | |
|---|---|
| Chas. M. Cresson, | J. Aitken Meigs, |
| George K. Crozer, | Benjamin V. Marsh, |
| William A. Drown, Jr., | Fairman Rogers, |
| John F. Frazer, | James S. Whitney, |
| Jas. A. Kirkpatrick, | Thomas J. Weygandt. |

Some cakes of Bentrinck's "kindling" were laid upon the table. They are composed of pine saw-dust and resin pressed in moulds whilst in a warm semi-fluid mass, and then permitted to harden. One cake, of about two inches square by one inch thick, is said to be sufficient to start a fire of wood.

Specimens of scale one and one-quarter inches thick, taken from the boiler of a steamer plying between New York and New Orleans, were shown as remarkable for thickness.

Mr. Samuel Solliday, of Sumneytown, Penna., sent a model of his safety casing for marine boilers. It is to be formed of very strong materials, and completely surrounds the boiler except at the top, which is closed by a light lid to exclude rain. Should an explosion take place, it is intended to be compelled to expend itself in an upward direction and prevent damage to the people or hull of the vessel.

Messrs. W. Wrightson and J. J. Thibault submitted to the meeting for examination a number of specimens of ores and minerals, when Mr. Wrightson made the following remarks:

The subject of the Silver Mines of Arizona was briefly presented to the meeting. Arizona extends from the Colorado river to the western boundary of Texas, and from the boundary of Mexico to the 34th parallel of north latitude. The portion between the Mexican boundary line and the Gila river is better known as the Gadsden purchase, and is the seat of all the improvements thus far made in Arizona. In an agricultural point of view this territory is comparatively of little value. Its arable land is confined to the narrow valleys of the streams where the banks are sufficiently level to admit of artificial irrigation by means of acequias or ditches. The most extensive and fertile of these valleys is that of the Rio Grande, in the neighborhood of the town of Mesilla, and is generally known as the Mesilla valley. It is about 20 miles in length and 10 in width. Its soil is exceedingly fertile and produces fine crops of corn and wheat. The waters of the river are taken in a large acequia at the northern extremity of this valley, and carried around the foot of the mountains and thence distributed in smaller acequias over the whole plain.

Viewed from the mountains on the west, this valley presents a beautiful appearance. Its level plain covered with rich vegetation, its acequias spread over its surface like a silver net, the Rio Grande flowing in silent majesty in the distance, towns of Mesilla and Las Cruces, and the houses of the farmers scattered here and there in the scene, while the whole landscape is shut in by the majestic range of the Organ mountains rising in almost perpendicular cliffs to the east. Next in importance to this are the valleys of the Sonoita and Santa Cruz, which include the settlements near Fort Buchanan and the towns of Tubac and Tucson. In addition to these are the valleys of the Mimbres, the San Pedro, and the Gila rivers; all of which contain some arable land. To the north of the Gila are said to be many fertile valleys now cultivated by the Indians. The whole surface of Arizona is well grassed, and it is possible that it will at some time be a grazing country.

Arizona derives its principal importance from its being a mineral region, and from the fact that the passes over the Rocky Mountains are lower here and more favorable to the construction of a railroad across the continent than on any other route. There seems to be a grand depression across the whole continent on the line of the Gulf of Mexico and the Gulf of California at the south, and the line of the great lakes at the north. This southern route through Arizona is the route of the 32d parallel, and affords both the shortest line and lowest passes and most favorable climate for the Pacific route. The mineral resources of Arizona are but beginning to be developed. The pioneers in this movement were a small exploring party sent out from Cincinnati in the spring of 1856. This party discovered and opened the Heintzelman mine, 20 miles west of Tubac, and are still working this mine. It is a vein of the grey sulphuret of silver and copper, yielding ores varying in richness from $ 100 to several thousand dollars per

ton; the average being $ 200 per ton. Near this mine are the Longorenia mine, the Arenilla mine, the Cahuabi mine, and a group of old mines on the Arivaca Ranche, yielding silver, copper, and lead. To the west of this group are the Ajo copper mines yielding ores from 60 to 80 per cent. of copper. To the east of the Heintzelman group are the Santa Rita mines opened by the Santa Rita Co. of Cincinnati. This group includes the Salero, the Ojero, and the Bustillo mines, which were worked extensively by the Spaniards previous to the Apache war, and the Crystal, the Gila, the Encarnacion, the Cazador, the Buena Ventura, the Tajito mines, which have been opened by this company. The mineral deposits of the Santa Rita are remarkable for the bold and extensive character of the veins. The mountain seems to have been tossed by some internal convulsion which shook and disturbed its whole mass, in some places filling the fissures with a dense crystalline mass of mineral, and in others depositing the metallic salts like soot in chimneys to the infernal regions. The Crystal mine is a dense compact vein of sulphuret of lead in steel grain crystals 20 inches in thickness, yielding 60 per cent. of lead, and having a small ley of silver. This vein outcrops on the surface nearly a mile in length. The Gila, Buena Ventura, and the Tajito mines are veins of the grey sulpuret of silver and copper, with threads of galena in large crystals. They are 5½ feet and 8 feet in width, and at the lower workings begin to yield native silver. Next, east from the group of the Santa Rita, are the mines of the Santa Cruz Mountains, including the Patagonia, the Empire, the San Antonio, the Trench, and others, yielding lead and silver. Eastward from these, at a distance not exceeding 30 miles, is another group of mines, yielding silver, copper, and lead, which is said to have given importance to the old Ranche of Babacomeri many years ago. They are not now worked. Passing eastward over an interval of 200 miles, in which veins of silver and copper ores and gold-bearing quartz are known to exist but are not yet taken up, are the Mimbres mine, including the Santa Rita del Cobre, the Hanover copper mines, the San José gold mines, the gold placers of the Mimbres, and several veins of silver and lead. The copper mines yield ores varying from 50 per cent. to native copper in great abundance. The copper of these mines is transported in wagons 1200 miles to the coast of the Gulf of Mexico, and thence by vessel to New York, at a profit on even this expensive transportation. The gold mines were worked originally by the Spaniards, but were abandoned at the time of the Apache war for want of better protection than was then afforded. They compare favorably with the best paying mines of California. Farther to the east, in the Organ mountains which line the valley of the Rio Grande, is the Stevenson mine, so called from Mr. Stevenson, of El Paso, who first opened this mine. It is a large bold vein of argentiferous galena, and is now worked by a company organized under the general laws of New York. In the same locality are the Santa Clara, the Santa Isabella, and other mines not now worked, but which are capable of yielding large masses of ore.

To the north of this chain of mines which have been here pointed

out, and which stretch for a space of 400 miles along the parallel of 32° north latitude, in the valley of the Gila river and near the meridian of 111° west longitude, is the Maricopa copper mine discovered by Col. A. B. Gray. It is a wide vein of the grey sulphuret of copper, and promises to be a mine of great importance; while all along the valley of the Gila are said to be deposits of gold-bearing quartz.

The specimens of ore exhibited to the Society were mainly from the Santa Rita and the Mimbres mines. They consisted of steel grained galena from the Crystal mine, Fahl ores from the Gila, the Buena Ventura, the Tajito mines; sulphuret of silver and copper from the Heintzelman mine; galena from the Bustillo mine; sulphuret and carbonate of copper and native copper from the Mimbres mines, and native gold and gold-bearing rock and dirt from the San José mine.

The attention of the Society was called to the commercial wants of Arizona, and the feasibility of a railroad route from Guamas or Port Lobos, on the Gulf of California, to Tubac, and thence by the route of the 32d parallel to the Rio Grande. The distance of Lobos to Tubac is 160 miles, over a route that is moderately level, presenting easy gradients and curves. The business to be done by such a road would be the transportation of ores and metals to the coast and return freight of provisions and merchandise to the mines.

The surface of the country is mostly gently rolling swells, the mountains rising abruptly and precipitously in small detached ranges rather than in continuous chains, thus affording an opportunity of winding around their bases. The prevailing rock is trap, and the soil hard gravel. In the absence of a railroad, it was thought wagons propelled by steam could be successfully adopted, the roads possessing all the requisites of hard surface, gentle ascents, and long stretches of straight lines.

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## METEOROLOGY.

For the Journal of the Franklin Institute.

*The Meteorology of Philadelphia.* By JAMES A. KIRKPATRICK, A.M.

JANUARY.—It will be seen by the accompanying table, that during the month of January of this year, the wind was more northerly than usual; the temperature and the force of vapor were lower, while the pressure of the atmosphere, the relative humidity, the amount of rain, and the number of rainy days were greater than usual.

The warmest day of the month was the 7th, of which the mean temperature was 41·7°, but the highest temperature (49½°) was reached on the 19th. The coldest day was the 13th, when the temperature fell to 1°, the mean for the day being 7·8°. It is said that in the western part of the city, about five miles west of the Schuylkill, the mercury fell to 6 degrees below zero on the morning of the 13th. The range for the month was 48½°.

The temperature was below the freezing point on 23 days of the month, though it rose above that point in the afternoon of every day

except six, namely, from the 11th to the 14th inclusive, and on the 23d and 31st.

The changes of temperature were less than usual for January, the mean daily range being less than six degrees, the average for ten years being a little more than six and three-quarters. The daily oscillation of temperature was three degrees less than in January, 1860, though it was only about a quarter of a degree less than the average for the month for ten years.

The pressure of the atmosphere was greatest (30·526 inches) on the morning of the 23d, and least (29·460) on the afternoon of the 16th; range for the month, 1·066 inches. The mean daily range, or average of changes in pressure, was considerably—that is, two-hundredths of an inch—more than usual, and eight-hundredths of an inch more than in the same month of last year.

Snow fell on eight days of the month, to the aggregate depth of about twelve inches. Between 9 and 10 A. M. of the 24th, the flakes of snow falling were very large, many of them being two inches in diameter, and so close to each other that for some time it was impossible to distinguish objects at the distance of one hundred yards.

There were nine days on which the sky was entirely covered with clouds, and four days clear or free from clouds at the hours of observation.

*A Comparison of some of the Meteorological Phenomena of* January, 1861, *with those of January*, 1860, *and of the same month for ten years, at Philadelphia.*

| | Jan., 1861. | Jan., 1860. | Jan., 10 years. |
|---|---|---|---|
| Thermometer.—Highest, . . | 49·5° | 58·0° | 62·0° |
| " Lowest, . . | 1·0 | 3.5 | —5·5 |
| " Daily oscillation, | 11·61 | 14·80 | 11·83 |
| " Mean daily range, | 5·98 | 6·50 | 6·78 |
| " Means at 7 A. M., | 27·67 | 28·89 | 27·29 |
| " " 2 P. M., | 34·34 | 38·37 | 35·09 |
| " " 9 P. M., | 30·90 | 32·97 | 30·81 |
| " " for the month, | 30·97 | 33·41 | 31·06 |
| Barometer.—Highest, . . | 30·526 in. | 30·399 in. | 30·704 in. |
| " Lowest, . . . . | 29·460 | 29·593 | 28·941 |
| " Mean daily range, . | ·229 | ·159 | ·208 |
| " Means at 7 A. M., . | 29·991 | 29·970 | 29·979 |
| " " 2 P. M., . | 29 953 | 29·915 | 29 941 |
| " " 9 P. M., . | 29·968 | 29·938 | 29 965 |
| " " for the month, | 29·971 | 29·941 | 29·962 |
| Force of Vapor.—Means at 7 A. M., | ·128 in. | ·136 in. | ·133 in. |
| " " " 2 P. M., | ·144 | ·144 | ·153 |
| " " " 9 P. M., | ·145 | ·143 | ·146 |
| Relative Humidity.—Means at 7 A. M., | 80 per ct. | 80 per ct. | 80 per ct. |
| " " " 2 P. M., | 72 | 61 | 69 |
| " " " 9 P. M., | 81 | 73 | 77 |
| Rain and melted snow, . . | 4·620 in. | 3·351 in. | 3·101 in. |
| No. of days on which rain or snow fell | 13 | 8 | 10 |
| Prevailing winds, . . . | N.52°12′W ·375 | N.89°9′ W ·402 | N.63°57′W ·343 |

*Abstract of Meteorological Observations for December,* 1860; *made in Philadelphia, Franklin, and Somerset Counties, Pennsylvania, for the Committee on Meteorology of the Franklin Institute.*

PHILADELPHIA.—Lat. 39° 57′ 28″ N. Long. 75° 10′ 28″ W. Height above the sea 50 feet. Prof. J. A. KIRKPATRICK, Observer.

| 1860. Dec. | Barometer. Mean. | Barometer. Mean daily range. | Thermometer. Mean. | Thermometer. Daily oscil-lation. | Thermometer. Mean daily range. | Force of vapor. 2 P.M. | Relative humi-dity. 2 P.M. | Rain and snow. | Prevail'g winds. |
|---|---|---|---|---|---|---|---|---|---|
| | Inch. | Inch. | ° | ° | ° | Inch. | Per ct. | Inches. | Direc. |
| 1 | 29·418 | ·109 | 34·2 | 18 | 6·7 | ·100 | 51 | | N W. |
| 2 | 29·618 | ·200 | 33·5 | 10 | 3·7 | ·134 | 64 | | W. |
| 3 | 29·818 | ·200 | 34·3 | 16 | 1·5 | ·108 | 45 | | N W. |
| 4 | 29 596 | ·222 | 33·7 | 7 | 4·0 | ·183 | 90 | 0·200 | (var.) |
| ☾ 5 | 29 659 | ·139 | 32·0 | 14 | 3·7 | ·083 | 38 | | W. |
| 6 | 29·705 | ·046 | 33·0 | 13 | 1·7 | ·127 | 60 | | W. |
| 7 | 29·857 | ·151 | 36·7 | 10 | 3·7 | ·155 | 60 | | S W. |
| 8 | 29·971 | ·114 | 34·2 | 5 | 3·8 | ·183 | 90 | 0·574 | N E. |
| 9 | 30·134 | ·163 | 29·8 | 8 | 4·3 | ·125 | 65 | | N. |
| 10 | 29·631 | ·523 | 36·0 | 14 | 6·2 | ·207 | 90 | 0·535 | (var.) |
| 11 | 29·712 | ·277 | 36·0 | 12 | 6·7 | ·180 | 85 | 0·014 | (var.) |
| ● 12 | 29·705 | ·122 | 34·0 | 12 | 5·3 | ·129 | 54 | | S W. |
| 13 | 29·742 | ·082 | 33·3 | 17 | 4·0 | ·115 | 47 | | W. |
| 14 | 30·300 | ·558 | 19·0 | 13 | 14·3 | ·056 | 45 | | N W. |
| 15 | 30·293 | ·110 | 17 3 | 6½ | 3·7 | ·070 | 68 | | N E. |
| 16 | 30·189 | ·104 | 25·8 | 20½ | 8·5 | ·106 | 55 | | S W. |
| 17 | 30·217 | ·049 | 33·5 | 19 | 7·7 | ·130 | 51 | | (var.) |
| 18 | 30 325 | ·108 | 30·3 | 12 | 4 5 | ·136 | 61 | | (var.) |
| 19 | 30·021 | ·304 | 35·3 | 15 | 5·0 | ·198 | 90 | 0·880 | N E. |
| ☽ 20 | 29·556 | ·665 | 42 7 | 11 | 7·3 | ·234 | 91 | | S W. |
| 21 | 29·658 | ·302 | 41·0 | 12 | 5·0 | ·166 | 53 | | W. |
| 22 | 29·607 | ·224 | 38·8 | 15 | 5·5 | ·170 | 65 | 0·243 | (var.) |
| 23 | 30·001 | ·393 | 28·7 | 9 | 10·2 | ·150 | 79 | | N W. |
| 24 | 30·092 | ·091 | 26·8 | 9 | 1·8 | ·075 | 45 | | N W. |
| 25 | 29 914 | ·178 | 29·0 | 12 | 2·2 | ·154 | 79 | | W N W |
| 26 | 30·091 | ·176 | 31·0 | 11 | 2·0 | ·141 | 69 | | N W. |
| ○ 27 | 30·220 | ·129 | 32·0 | 11 | 1·0 | ·127 | 60 | | N N W |
| 28 | 30·333 | ·113 | 30·3 | 7½ | 1·7 | ·138 | 70 | | (var.) |
| 29 | 30 345 | ·040 | 31·5 | 9 | 1·5 | ·138 | 70 | | (var.) |
| 30 | 30·228 | ·117 | 38·3 | 11 | 6·8 | ·198 | 74 | 0·855 | N E. |
| 31 | 30·247 | ·076 | 28·0 | 18 | 10·3 | ·123 | 77 | | N W. |
| Means | 29·936 | ·196 | 32·3 | 12 | 5·0 | ·140 | 66 | 3·301 | N 52° W |

CHAMBERSBURG, Franklin Co. Lat. 39° 58′ N. Long. 77° 45′ W. Height 618 ft. WM. HEYSER, Jr., Observer.

| Dec. | Barom. Mean. | Thermom. Mean. | Thermom. Mean daily range. | Force of vapor. 2 P.M. | Relative humi-dity. 2 P.M. | Rain and snow. | Prevail'g winds. |
|---|---|---|---|---|---|---|---|
| | Inch. | ° | ° | Inch. | Per ct | Inch. | Direc. |
| 1 | 28·835 | 29·0 | 11·7 | ·078 | 41 | | W. |
| 2 | 29·084 | 30·3 | 3·3 | ·067 | 34 | | W. |
| 3 | 29·221 | 34·0 | 3 7 | ·050 | 23 | | W. |
| 4 | 29 012 | 31·0 | 3·0 | ·155 | 79 | 0·200 | (var.) |
| 5 | 29 006 | 32·0 | 2·3 | ·166 | 55 | | (var ) |
| 6 | 29·050 | 32·0 | 2·0 | ·067 | 34 | | W. |
| 7 | 29·199 | 37·3 | 5·3 | ·155 | 58 | | W. |
| 8 | 29·309 | 39·0 | 1·7 | ·103 | 33 | 0·200 | N E. |
| 9 | 29 519 | 34·7 | 4·3 | ·165 | 72 | | (var.) |
| 10 | 28·902 | 39·0 | 4·3 | ·191 | 82 | 0·732 | (var.) |
| 11 | 29·110 | 34·0 | 5·7 | ·103 | 45 | | W. |
| 12 | 29 018 | 33·0 | 4·3 | ·165 | 72 | | W. |
| 13 | 29·152 | 30·7 | 4·3 | ·080 | 38 | | W. |
| 14 | 29·659 | 21·0 | 9·0 | ·025 | 24 | | W. |
| 15 | 29 688 | 18·3 | 3·3 | ·085 | 72 | 0·050 | W. |
| 16 | 29·561 | 20·0 | 8·3 | ·113 | 67 | | (var.) |
| 17 | 29·534 | 30·3 | 10·3 | ·126 | 49 | | (var.) |
| 18 | 29·651 | 31·3 | 5·7 | ·121 | 62 | | N E. |
| 19 | 29·349 | 28 7 | 2·7 | ·124 | 77 | 1·157 | N E. |
| 20 | 28·725 | 38·7 | 10·0 | ·181 | 73 | | W. |
| 21 | 28·968 | 38·3 | 2·3 | ·164 | 59 | | N E. |
| 22 | 29·021 | 33·7 | 7·3 | ·091 | 45 | | W. |
| 23 | 29·334 | 28·7 | 5·0 | ·090 | 50 | | W. |
| 24 | 29·478 | 24·7 | 4·0 | ·160 | 36 | | W. |
| 25 | 29·290 | 28·7 | 4·0 | ·130 | 78 | | (var.) |
| 26 | 29·508 | 31·0 | 2·3 | ·085 | 43 | | W. |
| 27 | 29·636 | 32·3 | 2·0 | ·166 | 55 | | W. |
| 28 | 29·677 | 31·3 | 1·0 | ·103 | 52 | | E. |
| 29 | 29·660 | 31·7 | 2·3 | ·168 | 89 | | N E. |
| 30 | 29·567 | 33·7 | 1·7 | ·191 | 90 | 0·600 | N W. |
| 31 | 29·638 | 22·0 | 11·7 | ·113 | 67 | | W. |
| Means | 29·207 | 31·0 | 4·8 | ·115 | 57 | 2·939 | N 47° W |

SOMERSET, Somerset Co. Lat. 40° N. Long. 79° 3′ W. Height 2195 feet. GEO. MOWRY, Observer.

| Dec. | Barom. Mean. | Thermom. Mean. | Thermom. Mean daily range. | Force of vapor. 2 P.M. | Relative humi-dity. 2 P.M. | Rain and snow. | Prevail'g winds. |
|---|---|---|---|---|---|---|---|
| | Inch. | ° | ° | Inch. | Per ct. | Inch. | Direc. |
| 1 | 27·231 | 20·7 | 4·7 | ·116 | 86 | | W. |
| 2 | 27·457 | 21·3 | 3·3 | ·099 | 79 | | W. |
| 3 | 27·546 | 27·3 | 6·0 | ·175 | 89 | | W. |
| 4 | 27·325 | 28·7 | 2·0 | ·190 | 95 | 0·136 | (var.) |
| 5 | 27·356 | 25·0 | 4·0 | ·140 | 88 | 0·149 | W. |
| 6 | 27 361 | 25·0 | 3·0 | ·128 | 81 | | W. |
| 7 | 27·558 | 33·0 | 8·0 | ·152 | 64 | | W. |
| 8 | 27·640 | 33·7 | 2·7 | ·177 | 85 | 0·332 | E. |
| 9 | 27 823 | 30·0 | 3 7 | ·142 | 69 | | E. |
| 10 | 27 250 | 28·0 | 8·0 | ·281 | 95 | 1·104 | (var.) |
| 11 | 27·489 | 26 3 | 11·7 | ·147 | 88 | 0·181 | W. |
| 12 | 27·344 | 26·7 | 4·3 | ·154 | 84 | | W. |
| 13 | 27·476 | 22 7 | 4·0 | ·095 | 54 | | W. |
| 14 | 27·911 | 14·3 | 8·3 | ·062 | 48 | | (var.) |
| 15 | 27·856 | 19·0 | 4·7 | ·115 | 75 | | S S E. |
| 16 | 27·843 | 30·7 | 11·7 | 168 | 65 | | W S W |
| 17 | 27 860 | 31·3 | 0·7 | ·133 | 50 | | ? |
| 18 | 27·867 | 32·0 | 4·7 | ·136 | 62 | | S E. |
| 19 | 27 585 | 32·3 | 3·0 | ·181 | 94 | 0·746 | S E. |
| 20 | 27·115 | 37·0 | 4·7 | ·216 | 91 | 0·091 | W. |
| 21 | 27·274 | 36·7 | 2·3 | ·203 | 82 | | W. |
| 22 | 27·475 | 24·0 | 12·7 | ·110 | 86 | | W N W |
| 23 | 27·709 | 23·0 | 5·0 | ·127 | 76 | | N W. |
| 24 | 27·840 | 21·3 | 4·3 | ·071 | 49 | | (var.) |
| 25 | 27·666 | 28·7 | 7·3 | ·186 | 81 | 0·173 | (var.) |
| 26 | 27·939 | 23·0 | 5·7 | ·097 | 67 | | W N W |
| 27 | 28·029 | 25·3 | 2·3 | ·121 | 75 | | W N W |
| 28 | 28 009 | 26·0 | 2·7 | ·155 | 79 | | E. |
| 29 | 27·962 | 24·7 | 4·0 | ·109 | 74 | | E S E. |
| 30 | 27·977 | 29·3 | 5·3 | ·191 | 90 | 0·421 | ? |
| 31 | 27·932 | 19·0 | 11·0 | ·108 | 65 | | W. |
| Means | 27·636 | 27·0 | 5·3 | ·145 | 76 | 3·333 | S 87° W |

*Abstract of Meteorological Observations for December, 1860; made in Adams, Dauphin, Northumberland, Centre, and Erie Counties, Pennsylvania, for the Committee on Meteorology of the Franklin Institute.*

| 1860. Dec. | Gettysburg, Adams Co. Lat. 39° 49′ N. Long. 77° 18′ W. Ht. 624 ft. Prof. M. Jacobs, Obs. Barom. Mean. | Thermom. Mean. | Thermom. Mean daily range. | Rain and snow. | Prevail'g winds. | Harrisburg, Dauphin Co. 40°16′, N. 76°50′, W. Ht., 300 ft. John Heisely, M.D., Obs. Barom. Mean. | Thermom. Mean. | Thermom. Mean daily range. | Rain and snow. | Prevail'g winds. |
|---|---|---|---|---|---|---|---|---|---|---|
| | Inch. | ° | ° | Inch. | Direc. | Inch. | ° | ° | Inch. | Direc. |
| 1 | 29·015 | 30·0 | 7·3 | | N W. | 29·226 | 33·0 | 6·0 | | W. |
| 2 | 29·264 | 28·3 | 3·7 | | W. | 29·505 | 33·7 | 2·7 | | N W. |
| 3 | 29·437 | 30·7 | 2·3 | | W. | 29·722 | 36·0 | 2·3 | | N W. |
| 4 | 29·285 | 26·3 | 5·7 | 0·095 | N N E. | 29·547 | 32·7 | 3·3 | 0·171 | N E. |
| ☾ 5 | 29·239 | 29·0 | 6·7 | | W. | 29·515 | 32·0 | 3·3 | | W. |
| 6 | 29·292 | 28·7 | 2·3 | | S W. | 29·573 | 31·3 | 2·7 | | W. |
| 7 | 29·448 | 33·3 | 5·7 | | W. | 29·717 | 36·0 | 4·7 | | S W. |
| 8 | 29·540 | 32·7 | 3·0 | 0·350 | (var.) | 29·826 | 35·3 | 2·0 | 0·500 | N E. |
| 9 | 29·751 | 32·7 | 2·0 | | (var.) | 30·033 | 35·3 | 2·0 | | W. |
| 10 | 29·137 | 36·0 | 4·0 | 0·570 | S. | 29·438 | 35·7 | 3·7 | 0·793 | E. |
| 11 | 29·341 | 31·7 | 5·7 | | N W. | 29·578 | 37·0 | 6·0 | | N W. |
| ● 12 | 29·206 | 31·7 | 6·7 | | N W. | 29·515 | 34·3 | 4·0 | | W. |
| 13 | 29·335 | 31·3 | 5·7 | | N W. | 29·627 | 32·0 | 3·7 | | N W. |
| 14 | 29·921 | 16·0 | 14·7 | | N W. | 30·192 | 21·7 | 10·3 | | N W. |
| 15 | 29·888 | 13·0 | 3·0 | 0·090 | (var.) | 30·198 | 16·3 | 5·3 | 0·050 | N E. |
| 16 | 29·787 | 18·0 | 11·7 | | S. | 30·083 | 23·3 | 7·0 | | (var.) |
| 17 | 29·819 | 27·7 | 6·3 | | S. | 30·122 | 30·3 | 7·0 | | N. |
| 18 | 29·880 | 26·0 | 3·0 | | N E. | 30·206 | 29·0 | 2·7 | | N E. |
| 19 | 29·583 | 29·0 | 2·3 | } 1·150 | N E. | 29·911 | 29·7 | 2·7 | } 1·063 | E. |
| ☽ 20 | 28·909 | 38·0 | 9·0 | | S. | 29·178 | 39·0 | 9·3 | | E. |
| 21 | 29·160 | 39·0 | 3·0 | | (var.) | 29·465 | 40·0 | 2·3 | | W. |
| 22 | 29·239 | 32·7 | 8·0 | | N W. | 29·472 | 36·0 | 4·7 | 0·069 | N W. |
| 23 | 29·569 | 27·0 | 5·3 | | N W. | 29·862 | 30·7 | 5·3 | | N W. |
| 24 | 29·707 | 21·7 | 5·3 | | (var.) | 30·006 | 27·3 | 3·3 | | N W. |
| 25 | 29·488 | 26·3 | 4·7 | 0·020 | N W. | | | | | N. |
| 26 | 29·730 | 29·3 | 3·0 | | N W. | 30·001 | 35·0 | | | N W. |
| ○ 27 | 29·858 | 27·0 | 3·7 | | N W. | 30·142 | 35·3 | 2·3 | | N W. |
| 28 | 29·950 | 29·0 | 4·0 | | N E. | 30·229 | 31·7 | 3·7 | | N E. |
| 29 | 29·007 | 29·7 | 1·0 | | S W. | 30·222 | 31·3 | 3·0 | | E. |
| 30 | 29·790 | 33·3 | 3·7 | } 0·705 | S W. | 30·093 | 34·3 | 3·0 | snow. | E. |
| 31 | 29·855 | 21·7 | 11·7 | | S W. | 30·145 | 27·7 | 6·7 | | N. |
| Means | 29·527 | 28·6 | 5·3 | 3·070 | N 58° W | 29·812 | 32·1 | 4·3 | 2·646 | N 29° W |

| 1860. Dec. | Shamokin, Northumberland Co. 40° 45′ N. 76° 30′ W. Height, 700 ft. P. Friel, Obs. Thermom. Mean. | Thermom. Mean daily range. | Rain and snow. | Prevail'g winds. | Fleming, Centre Co. 40° 55′ N. 77° 53′ W. Ht., 780 feet. S. Brugger, Obs. Thermom. Mean. | Thermom. Mean daily range. | Rain and snow. | Prevail'g winds. | Erie, Erie Co.—Lat. 42° 8′ N. Long. 80° 12′ W. Height about 610 feet. Benjamin Grant, Obs. Barom. Mean. | Thermom. Mean. | Thermom. Mean daily range. | Force of Vapor. 2 P. M. | Relative humidity. 2 P. M. | Rain and snow. | Prevail'g winds. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ° | ° | Inch. | Direc. | ° | ° | Inch. | Direc. | Inch. | ° | ° | Inch. | Per ct. | Inch. | Direc. |
| 1 | 30·0 | 10·3 | | W. | 26·7 | 13·7 | | N W. | 28·973 | 28·7 | 10·0 | ·129 | 78 | 0·450 | N W. |
| 2 | 30·3 | 2·3 | | W. | 28·3 | 2·3 | | N W. | 29·156 | 32·3 | 3·3 | ·131 | 70 | | W. |
| 3 | 32·0 | 1·7 | | W. | 30·7 | 2·3 | | N W. | 29·287 | 32·7 | 0·7 | ·131 | 70 | | W. |
| 4 | 30·2 | 3·2 | 0·200 | (var.) | 34·7 | 4·0 | 0·250 | E. | 29·131 | 33·7 | 2·3 | ·141 | 69 | | (var.) |
| ☾ 5 | 31·5 | 4·0 | | W. | 30·3 | 6·7 | | W. | 29·120 | 32·7 | 2·3 | ·150 | 79 | | N. |
| 6 | 27·7 | 4·8 | | W. | 28·0 | 5·3 | | W. | 29·047 | 29·0 | 3·7 | ·141 | 88 | } 0·600 | S W. |
| 7 | 32·0 | 4·7 | | W. | 32·0 | 4·7 | | W. | 29·247 | 33·7 | 7·3 | ·081 | 31 | | N W. |
| 8 | 33·3 | 2·3 | 0·300 | E. | 34·0 | 2·0 | 0·530 | S E. | 29·468 | 36·0 | 1·7 | ·150 | 63 | | E. |
| 9 | 30·0 | 3·3 | | E. | 31·0 | 3·3 | | (var.) | 29·557 | 36·7 | 0·7 | ·137 | 55 | | S W. |
| 10 | 33·3 | 3·3 | 0·361 | E. | 36·7 | 5·7 | 0·900 | S W. | 29·258 | 39·0 | 2·3 | ·207 | 75 | | (var.) |
| 11 | 34·0 | 4·0 | | W. | 30·0 | 8·0 | | N W. | 29·185 | 31·0 | 8·0 | ·155 | 89 | | N. |
| ● 12 | 31·0 | 4·3 | | W. | 31·7 | 3·0 | | W. | 29·226 | 30·7 | 3·7 | ·121 | 69 | | W. |
| 13 | 28·8 | 3·5 | | W. | 24·3 | 7·3 | | W. | 29·258 | 23·3 | 7·3 | ·072 | 59 | } 0·350 | W. |
| 14 | 15·3 | 13·7 | | W. | 12·0 | 12·3 | | N W. | 29·747 | 19·3 | 4·7 | ·106 | 86 | | N W. |
| 15 | 11·3 | 3·0 | | N E. | 5·0 | 7·0 | | E. | 29·617 | 22·3 | 7·0 | ·123 | 77 | | S. |
| 16 | 23·5 | 9·2 | | E. | 20·0 | 15·0 | | (var.) | 29·539 | 32·7 | 10·3 | ·114 | 52 | | W. |
| 17 | 26·8 | 3·7 | | W. | 26·7 | 11·3 | | W. | 29·643 | 33·0 | 1·7 | ·164 | 71 | | W. |
| 18 | 26·2 | 4·0 | | E. | 25·0 | 12·3 | | E. | 29·597 | 36·3 | 3·3 | ·112 | 62 | | S. |
| 19 | 29·0 | 9·2 | | E. | 33·7 | 9·7 | } 0·850 | E. | 29·012 | 42·0 | 5·7 | ·193 | 67 | } 0·560 | S. |
| ☽ 20 | 38·2 | 9·2 | 0·750 | (var.) | 37·0 | 2·3 | | W. | 29·261 | 41·3 | 4·0 | ·094 | 38 | | W. |
| 21 | 37·3 | 1·2 | | E. | 39·0 | 2·7 | 0·065 | W. | 28·940 | 37·0 | 4·3 | ·135 | 61 | } 0·600 | S W. |
| 22 | 36·3 | 3·0 | 0·200 | W. | 30·3 | 9·3 | | N W. | 29·108 | 28·7 | 8·3 | ·099 | 65 | | N W. |
| 23 | 26·2 | 10·8 | | (var.) | 22·0 | 8·3 | | W. | 29·500 | 27·0 | 6·3 | ·154 | 79 | | N W. |
| 24 | 23·2 | 3·0 | | W. | 19·7 | 5·0 | | N W. | 29·616 | 24·7 | 3·7 | ·148 | 89 | | N W. |
| 25 | 25·0 | 3·2 | | N W. | 17·3 | 5·7 | | N W. | 29·417 | 26·3 | 2·3 | ·136 | 78 | | E. |
| 26 | 29·7 | 4·7 | | W. | 21·7 | 5·7 | | W. | 29·717 | 31·0 | 4·7 | ·150 | 79 | | N W. |
| ○ 27 | 31·7 | 2·7 | | N W. | 23·0 | 2·0 | | W. | 29·827 | 32·3 | 1·3 | ·138 | 70 | | N E. |
| 28 | 26·0 | 5·7 | | (var.) | 25·3 | 4·3 | | E. | 29·759 | 33·7 | 1·3 | ·154 | 79 | | W. |
| 29 | 28·3 | 3·0 | | E. | 29·3 | 4·0 | | S E. | 29·506 | 34·0 | 1·7 | ·135 | 61 | | S. |
| 30 | 31·7 | 5·3 | 0·300 | E. | 32·3 | 3·0 | 0·400 | (var.) | 29·662 | 25·7 | 8·3 | ·093 | 64 | | W. |
| 31 | 22·3 | 11·3 | | W. | 12·3 | 20·0 | | W. | 29·742 | 22·0 | 3·7 | ·106 | 86 | | N W. |
| Means | 28·9 | 5·1 | 2·111 | N 78° W | 26·9 | 6·7 | 2·995 | N 66° W | 29·448 | 32·2 | 4·4 | ·133 | 70 | 2·560 | N 84° W |

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**APRIL, 1861.**

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## CIVIL ENGINEERING.

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Translated for the Journal of the Franklin Institute.

*Examination of some Questions relative to Transportation.* By M. Lamarle, Chief Engineer "des Ponts et Chaussées." Translated by J. Bennett.

The influence of the cost of transportation upon the products of industry, is now too well recognised to require comment. One of the chief causes of our inferiority in certain manufactures is due to the relative imperfection of our lines of communication; so that their development and improvement have been the constant object of the consideration and care of all the governments of the present century.

In this period, so fertile in improvements of this kind, a new fact of immense importance is produced; man, in this strife against distance, has fashioned an instrument of almost marvellous power, with a speed hitherto unknown, a nearly mathematical regularity, an unalterable constancy of service, and what was unexpected at the start, with a considerable economy in the cost of transportation. Such are the principal characteristics of this invention, which will remain in the history of material progress as the point of departure of a new era.

Thus railroads, notwithstanding the great capital they require, have rapidly multiplied; never has so costly an invention passed so largely and quickly into the domain of facts. Scarcely thirty years have passed since the meeting at Manchester, and more than 24,800 miles of roads in use have furrowed the soil of Europe, and over $200,000,000 have been devoted to the establishment of a net-work, which increases every

year. The united will of the people calls for new developments, whose limits cannot now be determined.*

This creation has notably changed the conditions of transportation; every year the railway draws to itself the most considerable masses of products, and is tending in a greater proportion to supply the places of the old traveled routes. In this respect it has exceeded the limits which could possibly be first assigned its influence, and its new action, scarcely foreseen and actively contested at an earlier date, but now certain and manifest, has raised questions of economy of great importance. We propose to investigate those which seem to have the most immediate interest.

2. The expense of transportation upon any route is divided into three principal parts:

1st. The interest of capital devoted to construction.
2d. The cost of maintenance.
3d. The expense of traction.

Sometimes capital is advanced by the State, the departments, and communes, without measures being taken to insure the payment of interest; this is the case with old roadways, which may course through all parts of the territory, and benefit the whole country. We need not specialize this part of the expense, which is merged in the general mass of taxes.

In other cases, the State procures by loans the funds required for effecting these new communications. It has then to provide for the payment of interest, and establishes tolls upon these lines, either to indemnify the amounts of their accounts, or for the payment of interest to the lenders. It is thus that the great canal system of 1821 has been executed.

Instead of loans, the government often grants to capitalists the right to make and collect determinate taxes for their remuneration. These grants are temporary or perpetual; in the first the company has to redeem the capital; in the second it is content with interest. A great number of canals and nearly all the railroads have been executed by concession, with or without subsidies from the public treasury.

The cost of maintenance of the way upon common roads is generally supported by taxes, with the exception of parish roads, where labor is called out to repair the wear and tear occasioned by the travel.

On navigable routes, the cost of maintenance as well as the interest of the first establishment should be covered by the tolls; only a portion of this expense, that of the use of the way, is sensibly proportional to the traffic, and would seem to be properly considered under the charge of traction.

This last, which constitutes the third element in the cost of transportation, is supported upon common roads and navigable routes by the commerce, which effects it with entire liberty. Upon railroads, on the other hand, the companies are held to operate all the transportation demanded of them, and receive in exchange a remunerating price.

* The lines conceded on the 31st December, 1857, amounted to 47,265 miles, of which 25,184 miles were open for travel.

Thus, they have to collect a tariff composed of two distinct parts: 1st, A *toll* representing the sum of general expenses, independent of the importance of the traffic; 2d, A tax upon transportation, corresponding with the expense of effecting it. The first part constitutes a public charge; it is an impost upon all merchandise, to liquidate the *constant* expenses of the enterprise; the second represents the reimbursement of expenses incurred by the company in the forwarding of merchandise; it varies with the development and conditions of circulation.

This in our opinion is an important distinction, and there will be occasion to refer to it.

3. We seek now to give an account of the value of these different elements, upon the different routes of communication.

For common roads, the cost of haulage, solely at the charge of trade, varies from 0·15 f. to 0·20 f.* per ton per kilometre (4·48 cts. to 5·98 cts. per ton per mile).

Upon navigable lines the taxes are quite various: all the navigable streams and rivers of the empire are subject to a toll of 0·0035 f. (0·104 cts.) per mile for first class merchandise, and 0·0015 f. (·045 cts.) per mile for second class. In the basins of the Aa and Escaut 0·005 f. is paid for the first class, and 0·002 f. for the second; upon other lines, the tolls, always referred to the ton and kilometre, varies from 0·01 f. to 0·109 f. (0·299 cts. to 3·27 cts.) per mile: the last tax, exceptional from its amount, answers to the Canal Saint-Denis, whose length is only 4·1 miles.

If we consider the somewhat extended navigable routes, as compared in this respect with competing railways, we have much less mean diverging results. In the following table are some which refer to the principal routes in the north of France:

| ROUTES. | Tolls. | Expense of Transportation. | TOTAL Per ton per kilo. | TOTAL Per ton per mile. |
|---|---|---|---|---|
| | fr. | fr | fr. | Cents. |
| From Mons to Paris, | 0 0117 | 0·0163 | 0·0280 | 0·8372 |
| " Charleroy to Paris, | 0·0143 | 0·0173 | 0·0316 | 0·9448 |
| " Mons to Lille, | 0·0102 | 0·0214 | 0·0316 | 0·9448 |
| " Dunkirk to Lille, | 0·0085 | 0·0187 | 0·0272 | 0·8133 |
| " Dunkirk to Cambria, | 0·0184 | 0·0208 | 0·0392 | 1·1721 |

The tariffs of railroads are uniform throughout France; they comprise four classes of merchandise, subject to the following taxes:

| CLASSES. | TAXES. Tolls. | Transportation. | Total. | Total per mile. |
|---|---|---|---|---|
| | fr. | fr. | fr. | cts. |
| 1st Class, | 0·10 | 0 080 | 0·18 | 5·38 |
| 2d Class, | 0 09 | 0 070 | 0·16 | 4·76 |
| 3d Class, | 0·08 | 0·060 | 0·14 | 4·18 |
| 4th Class, | 0·06 | 0·040 | 0 10 | 2·99 |

* Calling the franc 18·6 cts., multiply the francs per kilometre by 29·9 for its equivalent in cents per mile.

4. In comparing these prices, it would seem easy to form a clear idea of the distribution of circulation between the different routes passing between the same termini.

Railroads carrying at a cost of from 0·10 f. to 0·18 f. the ton, with a speed and regularity incomparably above that of common roads, must take preference, as the latter work at rates (0·15 f. to 0·20 f.) This is really the case, especially on long routes, where the advantage of the railway is more apparent.

As to navigable routes, less speedy and regular than the railroad, they present some economical advantages which should draw and retain all the heavy masses which without inconvenience can afford the delay. It would seem that they have only to lose the precious commodities, for which an increased price is preferable to the delays and damage incidental to long trips.

The facts at first sight would seem to confirm these previsions. If we examine the useful work accomplished by the navigation from 1850 to 1856, we find that it has not only not diminished, but has on the contrary increased nearly 33 per cent. in this period.

But if we discuss more carefully these results, if especially we take into account the development of traffic upon railroads, and the total increase of circulation, we arrive at very different consequences.

The following table gives a good view of this matter:

| DATES. | Work of 1000 tons carried one kil | | | Distribution between the two routes. | |
|---|---|---|---|---|---|
| | Navigable Lines | Railroads | In all. | Navigation. | Railroads. |
| | m. t. k. | m. t. k. | m. t. k. | | |
| 1850 | 1722000 | 355000 | 2077000 | 0·82 | 0·18 |
| 1851 | 2164000 | 889000 | 3053000 | 0 71 | 0·29 |
| 1852 | 2302000 | 1851007 | 4153007 | 0 55 | 0·45 |

We see from this table that the law of partition of traffic between the railroad and navigation has been greatly changed, to the prejudice of the latter. In 1850 it absorbed 82 per cent. of the carriage of bulky merchandise; in 1856 the proportion has been reduced to 55 per cent., hardly two-thirds. While the tonnage of navigation has thus increased only 33 per cent., in a progression whose ratio decreases each period, that of railroads has more than quintupled, with a velocity of increase yet in the ascendant.

Similar results have attended the transportation of Belgian oils to France. Here are some of the variations from 1852 to 1858:

| DATES | Partition of transportation by Navigation. | Railroads. | Remarks. |
|---|---|---|---|
| 1852 | 0 92 | 0·08 | Documents presented to |
| 1854 | 0 80 | 0·20 | the Council General of |
| 1856 | 0 75 | 0 25 | the North (1858). |
| 1858 | 0 52 | 0 48 | First 6 months, 1858. |

Here the decline is still more clearly marked, and the prosperity of the railroad is much more rapid. This example is the more remarka-

ble, in that it applies to oil, the chief support of the Northern canals, and one of the commodities which might be regarded *à priori* unquestionably adapted to the navigable routes.

In presence of these facts, it is impossible to ignore the powerful influence of the railroad upon the merchandise of canals, and, however little we examine the law which governs these developments, we cannot but foresee the moment when the progress of traffic upon the canals shall be utterly checked, and when the decline, already apparent upon some of the lines, shall be progressively extended to the whole network.

5. These results, which seem anomalous in presence of official tariffs, are yet easily explained in taking account of two essential circumstances.

1st. The length of water-ways is always greater than that of competing railways; the excess, sometimes as high as one-half, is most generally between the third and quarter of the railway; it therefore increases the cost of transportation.

2d. This influence, though sensible, does not yet account for the observed fact. The cause of the marked preference of which the railroad is the daily object, is especially due to the great reductions in the official rate of their tariffs agreed upon by the companies. A single example enables us to appreciate its whole reach. From Quiévrain to Paris, a distance of 279 kilometres (173 miles), tariffed for oil, at the rate of 0·10 f. per ton per kilometre (2·99 cts. per mile), at 27·9 f., the Northern company reduced the total tax to 10·50 f.

This amounts to 0·0376 f. per ton per kilometre (1·12 cts. per mile), and occurs wherever the railway carries oil for long distances.

Such great reductions no longer admit the illusions of economists, who twelve years ago, fixed the lowest limit of railroad tariffs at from 6 to 7 centimes per kilometre (1·79 cts. to 2·09 cts. per mile); and in face of their assurances, we may expect to see the competition of the railroad much more widely extended; it is what every day's experience shows us.

6. But the railroad companies, not content with this so great latitude of variations, have introduced, in the application of reduced tariffs, other important modifications, in accordance with the quantities, distance, and conditions of the transportation; these changes have been applied so as to produce some singular anomalies: thus for short distances, the total charges have been sometimes greater than for long distances. The powerful industrial and great commercial interests have been specially favored, and the degree in which these companies have used the new tariffs, seems to constitute a formidable power upon all the industry of the country.

Thus most of the chambers of commerce, and a great number of the general councils, have been roused at the importance of these measures; and have united their voice with that of the canal interests, to protest against these *discriminating* tariffs.

The companies have usually defended their new tariffs, and their system has obtained the outside support of officials of undoubted abil-

ity.* The importance of this question, and the influence which its solution must exert upon the public welfare, impose upon us the duty of examining it carefully in its general bearing and its details.

The differential tariffs are presented under various forms. Most frequently, they accord reductions in price, according to the extent of travel; the price to pay per kilometre diminishes with the increased number of kilometres; this is the *differential* tariff proper.

Sometimes the companies reduce the price of transportation between two localities not traversed by the railroad direct, to what it would be if the route existed: these are called *indirect* tariffs, (tarifs de detournement.)

At other times they stipulate for reductions in favor of foreign products, and this is called the *international* tariff.

Sometimes merchandise obtains, by reason of its nature, great reductions by the *special* tariffs.

In private contracts, considerable abatements are accorded to forwarders, who engage to fulfil certain conditions, stipulated in the bargain, among which is generally found that of furnishing a minimum tonnage.

Finally (*les abonnements*) or allowance in favor of those industrial interests who renounce all other modes of transportation but the railroad.

7. With some unimportant exceptions, the fundamental principle which controls these tariffs is:

"To reduce the price of the unit of traffic in favor of those industrial and commercial interests who guarantee the company the greatest number of units: to increase the reductions in the ratio of the increase of these quantities."

This principle we must admit has been applied in most enterprises of land and water carriage; and these reductions can only be ascribed to the single element at their disposal, the expense of transportation which they operate in all freedom at their risk and peril.

This precedent, which affords the authority of a universal and constant practice, is otherwise fully justified. It cannot be denied that the directors of transportation derive a real economy in its expenses, from the fact of important commands, assuring long carriage, considerable masses, and a better distributed movement. It is quite natural, that in view of this economy, it should offer better conditions to the forwarders, who procure it, and so restore with an intelligent equity, a part of the advantages which they bring; undoubtedly this disposition specially applies to the great industrial and extended commercial interests, but it results from the very essence of things; it is no favor, but a practical recognition of an unquestioned fact, the economy always obtained in operating upon a great scale.

That the ancient administrations of transportation should have combined their tariffs, in this so rational order of ideas, and that it should be applicable outside of railroads, is easily justified. That the rail-

*The author here refers to a memoir of M. Ed. Boinvillers, member of state council. Without partaking of all his opinions, he pays tribute to the clearness of his views and the merit of his researches.

road companies should claim the same faculty is also easily understood; but what we can in no case admit, is that these *exceptional* reductions should ever surpass the value of economies realized, by reason of the most favorable conditions of the great industrial transportation. That there should be rendered to it, and it alone, all or part of the economies, which it alone furnishes the means of realizing, is well; but there in our opinion, the *differential* action of the tariff should be stopped. Thus these reductions of taxes should in our opinion apply exclusively to that part of the official tariff only which answers to the expense of transportation, upon which alone rests the economy of the net price.

When the reduction passing this limit, reaches the imposts of tolls, it should we think, *be common to all*, because in France, since 1789, equality of imposts existed for all. Surely, then, the small and the weak can rightly reclaim this protecting equality, this exact proportionality of tolls, the common basis of our financial system, and public rights.

| | |
|---|---|
| To explain our idea, we resume the example of the reduction allowed for the transportation of oil between Quiévram and Paris, tarifled by their conditions at | 27·9 f. |
| To-day effected by the Northern Company at . . | 10·5 |
| Whence results a total reduction of . . | 17·4 |
| The conditions of contract fix the maximum rate of transportation at 0·04 f. per ton per kilometre, or for 279 kilometres, . . | 11·16 f. |
| On the other hand, it is known that in the best conditions possible, we cannot count upon an expense below 0·015 f. per ton per kilometre, or for 279 kilometres at least . . . . | 4·19 |
| The difference . . . | 6 97 |

Expresses then the maximum of possible economy upon the cost of transportation, by reason of the best conditions in mass, distance, and distribution. The total reduction of 17·40 f. accorded by the company, is composed then of two distinct parts:

| | |
|---|---|
| 1st. One, answering to the possible economy in the expense of transportation or the maximum as above, . . . . | 6 97 f. |
| 2d. The other, necessarily assignable to the tolls, equal at least to | 10·43 |
| Total reduction, . . . | 17·40 |

Here then the figure 6·97 f. represents, as we think, the *maximum of exceptional reductions* to be made in case of the most favorable conditions. The surplus constitutes, on the contrary, a part of the reduction necessarily assigned upon the tolls, upon *imposts.* In this respect the diminution it represents, should be extended to all transportations of the same nature, whatever may be their conditions. The small industrial departments should not be deprived of this reduction, without an injustice all the more to be regretted that it falls upon the most embarrassed part of the population.

The adoption of our opinion, would not in any case lead the railroad companies into operating at a loss, since they receive the integral of the taxes fixed for the expenses whenever the conditions of traffic may not afford any economy in this respect; they will thus be

repaid with the profit provided by contract for all expenses which they have incurred for transportation.

But if they judge best to effect new reductions upon the tolls, which do not correspond with any expense dependent upon traffic, they should we think be extended to all, because it is a veritable impost, which by its nature should be the same for all.

Far from opposing the differential tariffs as applied on account of the good market which they procure for certain freights, we reproach them, on the contrary, with rendering it relatively too dear for the majority of forwarders; what we contend against with all the energy of our conviction in the actual system, certainly is not the moderation of the taxes, but their elevation for the majority and the injustice which distributes the imposts of tolls precisely in the inverse ratio of the ability of those who have to pay them.

8. To prevent this injustice, and at the same time accounting to the great industrial interests for the economies which they alone have allowed them, it would suffice to determine in each particular case the value of reductions of expense resulting from the special conditions agreed upon for the freight, and to limit to this figure the maximum of *exceptional* advantages accorded to forwarders who accept them. Such should be the limit to assign to the differential elements of tariff.

Every reduction above this, falling then upon the tolls, should be made common for all freight of the same nature, whatever its importance, its production, and destination.

This rule, of an easy application, in its generality embraces, with the differential tariffs properly called the indirect tariffs, the international, special, and private bargains; but absolutely rejects the last class of tariffs or the tariff "d'abounement." In fact, the economy which such a condition procures for companies cannot be determined, since it cannot state precisely the quantity of merchandise assured to their traffic. Now to give the whole of its freight to the railroad, and obtain the same reduction, whatever the mass, is surely not to receive an equivalent for the economy it affords, but simply to receive a premium of the companies for uniting with them in the destruction of a rival interest.

(To be Continued.)

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*On Increased Brake Power for Stopping Railway Trains.* By Mr. Alexander Allen, of Perth.

From Newton's London Journal, August, 1860.

The subject of increased brake power, for stopping quick trains in a shorter distance than is at present practicable, has become of great importance, and the attention of railway companies has recently been specially drawn to it by the railway department of the Board of Trade, by whom a number of experiments were tried on brakes of engines and carriages; and a recommendation was made to the railway companies for carrying out a system of continuous brakes to the whole train. The subject was also recently under the consideration of a committee

of the House of Commons, before whom evidence was given on the causes of railway accidents; this evidence was in favor of increased brake power on the engine, if not too suddenly applied; for it was shown that no brake on the carriages could be applied quickly enough to prevent accidents.

The subject of this paper is a plan for obtaining increased brake power, by retarding the speed of the engine by means of a throttle-valve placed in the exhaust-pipe, which can be instantly closed to any required extent, so as to obstruct the exit of steam from the cylinders, the regulator remaining open; at the same time the exhaust steam is admitted to a small cylinder, the piston of which acts through levers upon a brake on the engine wheels.

In this arrangement, the spindle of the throttle-valve projects through the side of the smoke-box, and is worked from the foot-plate by means of a lever and a connecting-rod. The brake cylinder is 8 to 10 inches diameter. The exhaust steam is admitted into the bottom of the cylinder through a $1\frac{1}{4}$ inch pipe, provided with a cock, and acting on the underside of the piston, lifts the brake lever and presses the brake blocks against the wheels. The cock in the $1\frac{1}{4}$ inch pipe is worked from the foot-plate, by means of a lever turning loose on the spindle of the throttle-valve; the throttle-valve can thus be closed, without at the same time admitting the exhaust steam to the brake cylinder, while the latter can also be instantly applied in cases of sudden emergency. When the steam pressure is removed from the cylinder, the weight of the piston and lever draws the brake blocks back clear of the wheels; the brake cylinder being contiguous to the smoke-box, and the pipe leading to it short and open to the heat in the exhaust pipe, there is no risk of water accumulating in the cylinder to prevent the descent of the piston when the steam pressure is removed. The brake blocks being under the charge of the engineman and fireman, will be regularly adjusted by them.

The brake cylinder applies the brakes simultaneously to the leading and trailing wheels of the engine, and the driving wheels are at the same time retarded by the back pressure of the exhaust steam on the pistons, consequent upon the closing of the throttle-valve in the exhaust pipe; the pressure of steam in the brake cylinder is the same as the back pressure in the driving cylinders, both being regulated by the extent of closing of the throttle-valve The power of the brake cylinder is limited, so as not to skid any of the wheels, in order to avoid wearing flat places on the tyres, and to produce the greatest effect in retarding the speed; a brake power of from 14 to 22 tons can thus be obtained by the steam brake alone. The brake power obtained by the use of the throttle-valve alone, retarding the driving-wheels of the engine, is equal to that of the tender brake, the regulator being open to the driving cylinders all the time. The application of the steam brake by the engineman may be followed immediately by that of the tender brake by the fireman, and the guard's brake in the van next to the tender; thus giving at once a greater brake power than has usually been applied in retarding trains, and diminishing the liability to accidents from want of sufficient brake power.

For the ordinary stoppages, the throttle-valve can be used to bring the train nearly to a stand, the tender brake being applied for the last few yards only; this will effect a great saving in the permanent way, tender, tyres and brake-blocks. By partially closing the throttle-valve, trains may be controlled to any desired speed in passing down an incline, while a great surplus of brake power is reserved in the steam brake cylinder, and the tender and van brakes, to bring the train to a stand quickly on the incline. In an experiment made with a gross load of 200 to 210 tons, down an average incline of 1 in 80, of 5 miles length, the train was controlled by the throttle-valve alone, from a speed of 30 miles per hour at starting, to 15 miles per hour down the whole incline. In approaching stations half the time may be saved by the joint use of the tender brake and the throttle-valve alone in the exhaust pipe, and a still further saving of time effected by also admitting the steam to the brake cylinder. By using the steam brake for ordinary purposes in place of the tender brake, there is less risk of heating and flattening the tyres, since the steam brake is so arranged as not to skid the wheels.

In this method of obtaining brake power from the engine, the speedy reversing of the engine valve gear from forward to backward gear is rendered an easy operation, whereby a further increase of retarding power is obtained; for the exhaust steam at the back of the driving pistons being compressed in the exhaust port by the closing of the throttle-valve, the pressure of steam inside the slide valves becomes equal to or greater than that outside in the steam chest, so that a balance of pressure is established, enabling the valves to be reversed instantly with perfect ease. The partial closing of the throttle-valve may be employed to prevent violent slipping of the driving wheels, which will revolve only in proportion to the quantity of steam allowed to escape from the exhaust pipe, and this may be regulated to any extent by the throttle-valve, which can be worked with greater ease and nicety than the regulator.

The retarding power of this steam brake was tested by the writer on the Scottish Central Railway. In the first two trials, only the throttle-valve in the exhaust-pipe was used, without the addition of the steam brake cylinder, thus retarding only the driving wheels of the engine by the back pressure of the exhaust; the third trial was made with an engine having the steam brake cylinder in addition to the throttle-vale.

From these experiments, it appeared that the retarding power produced by closing the throttle-valve in the exhaust pipe was fully equal to that of the tender brake; and the engine steam brake also produced an effect fully equal to the tender brake; so that, by employing both throttle-valve and steam brake in conjunction with the tender brake, the retarding power obtained was more than double that of the ordinary tender brake alone.

Mr. R. Morrison remarked, that he had seen some experiments upon a steep incline of 1 in 40 on the Edinburgh and Glasgow Railway, with a steam brake contrived by Mr. Paton, which gave a very power-

ful retarding force; the brake was applied to the leading and trailing wheels of a large tank engine having all the wheels coupled, and the pressure was produced by a steam cylinder communicating direct with the boiler. The action of the brake was very efficient, but he believed the principal objection to it was found to be the great shock caused by its sudden application, which often deranged the levers of the apparatus, and occasioned an objectionable concussion to the train.

Mr. Allen said that, with the plan of the throttle-valve in the exhaust-pipe, this objection was removed, as the pressure came on gradually by the gradual compression of the exhaust steam; and no objectionable shock was perceived beyond what was of course unavoidable in stopping a quick-moving train within a short distance: a train at a speed of 40 miles per hour was stopped in 150 yards upon a level, by means of the steam brake and tender brake, without any objectionable shock being produced.

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## *Repairs and Renewal of the Roche-Bernard Suspension Bridge.* From a description given by M. Noyon, Engineer. Translated by J. Bennett.

### Part Second.

(Continued from page 156.)

*Correction of Camber of Platform.*—The platform, in obedience to all the movements of the primitive suspension bundles, must consequently rise in its middle 0·55 ft., and its camber, which at the mean temperature of 20° Centigrade (68° Fah.) stood at 4·26 ft., would attain 4·92 ft. at —5° (23° Fah.), and would occasionally be at $4·92 + 0·55 = 5·47$ ft. Now, as the platform had too marked a rise in its primitive position, it seemed necessary to diminish the sagitta, so as to correct the effect of establishing the additional cable, as well as to remedy the inconvenience of the proximity of the cables and platform, with the chances of the yokes of the central part rubbing against the stringers of side-walks. It was accordingly reduced 0·88 ft.; so that the camber was never to exceed 4·59 ft.

To accomplish this, the suspension rods had all to be removed and their lengths changed. Some were shortened, others simply removed some rows towards the centre, and those lengthened which were to be hooked upon the new cables.

Advantage was taken of this circumstance in correcting a fault of 2·75 ins. of level which was found between the sides of the flooring. It would have been a long job by calculation, but a graphical method indicated in the *Annales des Ponts et Chaussées* (2d series, tome xx, p. 509) was used, whose correctness was fully confirmed in this new application.

During the removal and restoration of the rods thus corrected, the beams were suspended upon the cables by four strong tackles, two at each end, so that they could be raised and freed from the stirrups and

the rods removed. This operation was effected symmetrically on each side, and to avoid confusion on the removal of the rod, care was taken to substitute in the number of its order another number corresponding with a table, giving the changes to be definitely assigned them.

*Replacing the Rods.*—The placing of the rods borne by the primitive cables was easily effected; not so, however, with those suspended from additional cable; for there was much difficulty in bringing the latter to its final position, not only from their great distance from the old cable, but from the successive derangements it experienced in proportion as its extremities were loaded. Attempts were made to bring them together by powerful screws and rope lashings, but only a few of the rods near the porches could be placed by this means, and to secure a good position for the placing of the others, the platform had to be suspended to the supplementary cable; the rods were furnished with lengthening pieces, which were successively shortened and suppressed when the cables were sufficiently close.

The difficulties were greater, since the lowering of the supplementary cable was only 1·47 ft. instead of 1·80 ft. as supposed; the difference is due to not accounting for the friction of the supplementary cables upon the sheetings of the old cables; for it is evident that an isolated wire, such as was used, moves more freely than a layer composed of 1400 wires with a width of 31·50 ins. and a thickness of from 1·4 to 2 ins.

Though this result was not unexpected it seemed prudent not to depart from the figures, which had been arrived at by two different means; the error, if it was one, seemed to incur less inconvenience than might have followed from the increased sagitta. Too great a distance between the cables would have appeared badly, while it was feared that too great a lowering of the supplementary cable would have prevented its bearing all the load reserved for it and cause much difficulty in preparing the rods.

*Actual Rise of the Platform.*—The platform actually rose 0·46 ft. Consequently, the summit of the new cables must have descended under the load $1{\cdot}80 - (0{\cdot}46 + 0{\cdot}33) = 1{\cdot}01$ ft.

*Establishment of the Counter-cables. Their Position and Form.*—Each counter-cable described between the points of attachment, and in a plane inclined 77° to the horizon, a curve, which, supposed to be plane, was nearly a parabola with a chord of 207·78 yards and a rise of 8·75 yards. It was composed of 600 No. 19 wires, forming a cylindrical bundle 4·33 ins. diameter.

*Mooring Anchors.*—Four wrought iron anchors 4·33 ins. square, being bent at right angles, embrace the masonry of the porches and are countersunk in the same, thus constituting the mooring system of the counter-cables.

The branches perpendicular to the axis of the bridge enter 5·25 ft. the piers of the arcades next the tower, and are connected two and two upon each bank by two strong bars of iron 2·75 ins. square with an eye at their ends, through which passes a dowel 2·36 ins. diameter, passing also through the anchors. The latter have a development

of 32·75 ft. and weigh each 2238 lbs. They were forged and puddled with great care at Rive-de-Gier, in the foundries of MM. Jackson, Petin, Gaudet & Co.

*Rods and Suspension Stirrups.*—The counter-cables (Plate III, Fig. 3) are suspended from suspension beams by round iron rods 1 inch diameter, with a hook at one end and an eye at the other, through which passes a reversed iron stirrup of the same dimensions whose branches and cross-piece are arranged so as to embrace exactly the end of the beam.

In the middle of the bridge this mode is impracticable on account of the small space between the bottom of the flooring and top of counter-cable; the latter is therefore connected with the 21 central beams by a system of bridles shown in Plate III, Fig. 4.

The branches of these bridles, as well as those of all the stirrups, have a worm 4·3 ins. long, by which the counter-cable can be raised or lowered.

The stirrups, as well as the double bridles, abut against the inner faces of the outer stringers and are hid beneath sidewalks.

*Fabrication of Counter-cables.*—They were made on site of bridge, but in an inverse order from definitive position.

Upon each head of bridge a standard wire, whose length was deduced from the rise and chord of the final curve, was stretched in the direction A E C (Plate III, Fig. 1) between the mooring anchors, and served as an indicator for placing all the wires in the corresponding cable.

A carrier, starting from the point Q upon right bank, unrols the wire, one of whose ends have been attached to the anchor C and passes from Q to R, always having the roll at arms length and outside of suspension rods. On coming near the left bank, at R, he stops a moment to give the workmen upon the scaffolding *v′ u′* time to draw the unrolled wire towards them, to hook it upon end of anchor A, and to return the end; he then returns towards Q, while with the windlass T the portion A K C of the wire is stretched so as to coincide with the regulating wire A E C; it is held in this position by an iron vice. Performing the same operation, by means of the windlass T, upon the wire passing from R to Q, a second element of the cable is obtained, and so on to the end; only the different wires once in place serve as standards for all that are to come upon them.

An agent placed upon the small foot-bridge *z s* suspended under the bridge and in the line of its transverse axis, watched for the coincidence of the wires among themselves or with the standard, and by signs from him those in charge of the winches T and T′ were guided in increasing or diminishing the tensions of the wires.

Each wire in its passage from one bank to the other was sustained by small bars projecting from the ends of the beams, and when its ends were hung upon the two anchors, it was dropped in the position A K C (Plate III, Fig. 1).

As the wires were put in place they were formed into bundles of 50 strands; these bundles were successively united by temporary liga-

tures. Without this precaution the wind would have impressed them with a continual motion, making it difficult to regulate the others.

The transfer of the wires from one bank to the other was effected upon the bridge itself, thus compelling the holding of the rolls at arms length, and the unrolling to be made beyond the suspension rods.

This was a troublesome condition and delayed the work; otherwise there would have been required foot-bridges upon each side of the platform and outside of the railing, or workmen would have to be posted upon the summits of the porches and raise the wires by hand.

These arrangements, besides being expensive, would be attended with risk, and it was thought best to take more time than to needlessly expose the lives of the workmen.

*Cost of putting up the Counter-cables.*—The two counter-cables were made in 22 days of effective work, with a force of 20 men: 6 cablers, 12 workmen, an assistant, and an agent specially charged with regulation of wires.

At the rate of $9·20 per day, the total cost was $22 \times 9{\cdot}20 = \$202{\cdot}40$; which is 16·8 cents per wire, or ·54 cents per ℔. This is but half the price generally given to master cablers for making and putting up by contract the common cables of suspension bridges.

*Ligatures of the Counter-cables.*—Before making the ligatures of the counter-cables, they are to be suspended from the platform of the bridge. For that purpose they were seized at sixteen points by strong tackles attached to the old cables; then, having raised them to the proper height, they were held by twenty-one rods distributed along the whole span.

In this position the counter-cables are sufficiently stiff to receive the small scaffolding (Plate III, Fig. 5) upon which are placed the workmen in charge of the ligatures.

This scaffolding, formed of a large plank with two ($i\,k$) hooks in front and two cords upon the back, which secured it both upon the counter-cable and upon two of the bridge beams, was very solid and easily managed.

The cablers employed upon the ligatures were also provided with a safety girdle, the cord $u$ of which was attached, on each station, to the hand-railing $l$ of the bridge.

*Oiling the Wires.*—The workmen to whom this duty was intrusted traveled horse-back fashion from the summit to the ends of the cable, upon a kind of saddle with stirrups which they themselves could slide. All were provided with a safety belt, whose cord was held by a workman upon the bridge who accompanied them throughout.

*Mastic of Cables.*—In a similar manner the mastic of the cables was laid on; only this part of the work was deferred till the suspension rods had been definitely placed.

*Effects of Change of Temperature on the System of Cables.*—As has been said, the counter-cables are designed to oppose the vertical motions produced by the wind, and their efficacy is due solely to the solidity existing between them and the other cables. This solidity seemed to present a serious inconvenience, resulting from the contrac-

tions due to the lowering of temperature. So that before executing this part of the work prescribed for the consolidation of the bridge, it was proper to consider the amount of inconvenience and to study some mode of remedying it while adhering to the disposition ordered by the administration.

The solution of this question depending upon the influence really exerted by changes of weather upon the wires united in bundles, for clearing up this matter numerous observations were made at different times, both upon the Saint Christopher bridge, near Lorient, and upon the Roche-Bernard.

It is generally admitted that the amount of elongation or contraction of an iron rod for 1° Centigrade is 0·0000122 ft. per foot, or for 1° Fah., 0·00000677 ft. per foot; but this is on the supposition that the action is of sufficient duration to be imparted to the different molecules of the metal. Now this condition is not fulfilled in the cables of suspension bridges: first, because from the daily changes in temperature the effects are transitory, and even in those hours when the temperature is stationary the different elements of the cables are not equally sensitive when grouped in bundles of from 4 to 7 ins. diameter, separated from each other as they are by fat unguents, painting, mastic, &c., all poor conductors of heat.

It was important to know the difference between the results of calculation and the data of observation.

To obtain the actual expansion of the cables, the sagitta of the parabolic bundles of the above named bridges were measured directly at different temperatures, and from the excess of each above the smallest was deduced the corresponding elongation of the cables by the following considerations.

According to Navier (Memoire sur les ponts suspendus, 2d edition, p. 139) the depression of the bridge flooring, resulting from a small increase $\gamma$ in the half length $h$ of the the cables, is given (the primitive sagitta being equal to $f$) by the relation

$$(1) \qquad \phi = \frac{3\,h}{4\,f}\,\gamma,$$

which may be written under the form

$$(2) \qquad \gamma = \frac{4\,f}{3\,h}\,\phi.$$

On the other hand, as the weight of the flooring holds the cables constantly stretched in all parts, whatever the temperature, the elongation produced by heat in the retaining bundles R M, N T (Plate III, Fig. 6), must be nearly entirely added to that arising from the expansion of the suspension bundles.

Consequently, if we place successively in the formula (2) instead of $\phi$ the increased lengths of the sagitta $f$, the values of $\gamma$ will approximately represent the real expansions of the portion R M S of cables by their corresponding changes of temperature.

In this way the numbers in the 6th column of the table B were calculated in making $f = 48{\cdot}42$ ft. and $h = 317{\cdot}58$ ft. for the Roche-

Bernard bridge, and $f = 45{\cdot}73$ ft. and $h = 298{\cdot}22$ ft. for the Lorient.

The figures of column 7 are deduced from the relation

$$\gamma' = 0{\cdot}0000122 \text{ L } t \qquad \text{(metrical units)},$$
$$\text{or} \quad \gamma' = 0{\cdot}00000677 \text{ L } t \qquad \text{(units of feet)},$$

in which $t$ represents the difference between the height of thermometer at the time of measurement of any sagitta and that indicated at the smallest of them, and L the development of the portion R M S of cables, which was 574·14 ft. or 475·71 ft., according as the formula was applied to the one or the other of the bridges.

A comparison of columns 7 and 8 shows that the ratio between the real and calculated expansions is 0·58 for the Saint Christophe and 0·78 for the Roche-Bernard bridge. Consequently, in dealing with analogous metallic bundles of suspension bridges, the co-efficient of expansion should be reduced

$$0{\cdot}00000677 \times 0{\cdot}78 = 0{\cdot}00000528 \qquad \text{(units of feet)}.$$

The disagreement for some of the observations between the variations of sagittæ and those of thermometer, is due solely to the inequality of temperature in the cables and air. We have also, from a comparison of the columns 3 and 5, for the mean expansion or contraction of the sagitta, for each degree of heat or cold,

0·007 m. for Roche-Bernard, or 0·0127 ft. 1° Fah.
and 0·005 m. for Saint Christophe, or 0·0091 ft. "

This being the case, let us consider a common suspension cable M S N (Plate III, Fig. 6) and a counter-cable A C B connected by rigid rods, and the latter to have been laid at a time when the temperature was $t°$. If the temperature increases, the bundle M S N will lengthen, and the middle of the flooring and the summit C of the counter-cable will fall a length equal to that which S has fallen. Moreover, the counter-cable also expanding will have less tension than at the time of its laying, and the small catenaries which it describes between the suspension rods will take a greater sagitta; but this circumstance has but a secondary interest and we need not dwell upon it.

When, on the contrary, the temperature lowers, the two cables which, were they independent of each other, would contract and take the respective positions M S′ N, A C′ B, lengthen in virtue of their extensibility, so that the distance of their summits remains nearly the same and the effects of contraction are thus compensated. From this arises a new tension, P, which is always relatively much greater for the counter-cable, whose section is generally less than that of suspension cable. To determine this tension, we will suppose that for an instant the latter is not counteracted in its movements, and that the counter-cable only yields, and elongates the necessary quantity for the summit of the cable M S N to be freely transported from S to S′.

Designating by $f$ and $f'$, $\omega$ and $\omega'$, the respective sagittæ and sections of the cable and counter-cable; by $2\,l$ the development of the first, and by $2\,l'$ that of the second, and by $h$ the half span, we have, for a falling of temperature of $t°$, a contraction of the suspension cable

expressed by $2\,l\,a\,t$ ($a$ being the real co-efficient of expansion), to which corresponds (formula 1) a contraction from the initial sagitta:

$$\phi = \frac{3\,h}{4\,f}\,l\,a\,t;$$

for the counter-cable, the contraction of the sagitta from this same falling of temperature will be

$$\phi' = \frac{3\,h}{4\,f'}\,l'\,a\,t.$$

Consequently, if the counter-cable alone supports the tension P, its sagitta will have an increase equal to

$$\phi + \phi' = \tfrac{3}{4}\,h\,a\,t\left(\frac{l}{f} + \frac{l'}{f'}\right).$$

And therefore its length will be increased (formula 2) by the quantity

$$2\,\gamma = 2\,\frac{4\,f'}{3\,h} \times \tfrac{3}{4}\,h\,a\,t\left(\frac{l}{f} + \frac{l'}{f'}\right) = 2\,a\,t\left(\frac{f\,l}{f'} + l'\right).$$

Now the force P′ necessary to elongate an iron bar of the length $2\,l'$ by the quantity $2\,\gamma$ is given by the relation

$$\text{(3)} \qquad \text{P}' = \frac{\text{E}\,\omega'}{2\,l'}\,2\,\gamma;*$$

$\omega'$ being the section of the bar expressed in square feet, and E the coefficient of elasticity, which is supposed equal 22000 kilogrammes per square millimetre, or 4507552379 lbs. per square foot.

Consequently, the effort experienced by the counter-cable has for its expression

$$\text{(4)} \qquad \text{P}' = \frac{\text{E}\,\omega'}{2\,l'}\,2\,a\,t\left(\frac{f'\,l}{f} + l'\right) = \text{E}\,\omega'\left(1 + \frac{f'\,l}{f\,l'}\right)a\,t.$$

This quantity P′ is evidently a superior limit of the tension P; for by reason of the solidity existing between the counter-cable and the suspension cable, the latter experiences this same tension, and its summit, instead of rising to the point S′, stops a little below at S″, for example; so that in reality the counter-cable is only elongated by the quantity $2\,\gamma$ diminished by the increased length $2\,\gamma'$ which would be produced in the suspension cable by the application of the force P.

In truth, this increase is not known, but its value may be nearly obtained when it is considered as differing but little from that which the force P′ found above would determine in the entire suspension cable; for then the extension of the wire due to this force being equal (formulæ 3 and 4) to

$$2\,\gamma' = \frac{2\,\text{P}'\,l}{\text{E}\,\omega} = 2\,\frac{l\,\omega'}{\omega}\left(1 + \frac{f'\,l}{f\,l'}\right)a\,t,$$

we have (formula 1), for the corresponding increase in the sagitta of the curve,

$$\phi'' = \frac{3\,f\,l\,\omega'}{4\,h\,\omega}\left(1 + \frac{f'\,l}{f\,l'}\right)a\,t.$$

* In original $2\,\text{E}\,\omega$; not correct.

Consequently, the increase in the sagitta of the counter-cable would be reduced to

$$(\phi + \phi') - \phi'' = \tfrac{3}{4} h\, a\, t \left[\frac{l}{f} + \frac{l'}{f'} - \frac{l\,\omega'}{f\,\omega}\left(1 + \frac{f\,l}{f\,l'}\right)\right].$$

To this variation of sagitta answers an extension of the counter-cable inferior to $2\,\gamma$ and equal (formula 2) to

$$2\,\gamma'' = 2\,a\,t\left[\frac{f'\,l}{f} + l' - \frac{f'\,l\,\omega'}{f\,\omega}\left(1 + \frac{f'\,l}{f\,l'}\right)\right].$$

But this may be considered as produced by a force $P''$ having for expression

$$P'' = \frac{E\,\omega'}{2\,l'}\,2\,\gamma'' = E\,a\,t\,\omega'\left[\frac{f'\,l}{f\,l'} + 1 - \frac{f'\,l\,\omega'}{f\,l'\,\omega}\left(1 + \frac{f'\,l}{f\,l'}\right)\right]$$

$$= E\,a\,t\,\omega'\left[\left(1 + \frac{f'\,l}{f\,l'}\right)\left(1 - \frac{f'\,l\,\omega'}{f\,l'\,\omega}\right)\right].$$

Now this quantity is an inferior limit of the tension sought, $P$, and, consequently, the mean, $\frac{P' + \rho''}{2}$, may be regarded as a near approach to the value of this tension.

To apply these formulæ to the Roche-Bernard bridge, we suppose

$$f = 48{\cdot}55 \text{ ft.}, f' = 24{\cdot}93 \text{ ft.}, l = 574{\cdot}14 \text{ ft.}, l' = 313{\cdot}31 \text{ ft.},$$
$$\omega = 0{\cdot}41034 \text{ sq. ft., and } \omega' = 0{\cdot}0586 \text{ sq. ft.}$$

Moreover, according to the results of observations upon the expansion of cables, we should give to the co-efficient $a$ the value 0·00000528 instead of 0·00000677, admitting 45° (Fah.) as the lowest range of the thermometer below that of the day when the standard wire was set, for the making of counter-cable we have

$$P' = 121768 \text{ lbs., and } P'' = 105447 \text{ lbs.,}$$

whence $$P = \frac{P' + \rho''}{2} = 113607 \text{ lbs.}$$

The absolute force $P$ represents an increase of tension of 1921 lbs. per sq. in. for suspension cable, and 13460 lbs. for the lower cable.

From this it appears there is no need of being concerned for the action of the counter-cable upon the system of suspension properly called, while it is important to reduce as much as possible the inverse effect, so that no cause may intervene at a given moment to diminish the force of the counter-cable against violent shocks transmitted by the platform when agitated by the wind.

*Means of preventing the effect of changes of Temperature upon the counter-cable.*—The most simple method of obviating this inconvenience would evidently be to increase the normal length of counter-cable by a small quantity, $\rho$, such that, even in the lowest temperatures, it may contract without difficulty, permitting the suspension cable to move as if it were free.

This small increase in length distributed uniformly over the curve would not impair the rigidity, and will suffice to compensate the occa-

sional contractions from the lowering of temperature. Thus the counter-cable, instead of taking the position A C′ B, will be drawn from A C B to A C″ B by the suspension cable, even when the latter has attained its extreme position M S″ N; and all the points of one will rise an equal quantity with the corresponding points of the other.

In fact, the summit C, in its removal to C″, allows the summit S to be displaced an equal quantity S S″ = C C″ = $\phi$ in the same direction; and as the tensions developed during these movements in the two parabolas M S N and A C B are distributed nearly uniformly upon the horizontal U V = $2h$, the curves M S″ N and A C″ B may be regarded also as parabolas.

But the equations of the lines M S N and M S″ N referred to the coordinates O X and O Y, and in regard to the previously adopted notations being respectively

$$y = \frac{f}{h^2} x^2 + \text{O S}$$

and

$$y = \frac{f - \phi}{h^2} x^2 + \phi \text{ O S}.$$

The difference $b\,b' = d$ of their corresponding ordinates $a\,b$ and $a\,b'$ is found equal to

$$d = \frac{f - \phi}{h^2} x^2 + \phi - \frac{f}{h^2} x^2 = \phi \left(1 - \frac{x^2}{h^2}\right).$$

This expression, in which the constants $\phi$ and $h$ only enter, shows that for the two other parabolæ A C B and A C″ B, whose summits are the same distance, $\phi$, apart, the difference of the ordinates will be deduced from a similar formula.

*Definitive Sagitta of Counter-cables.*—It was natural to adopt the means just indicated; and as the counter-cables were made at their site by means of a standard wire which was established at a temperature of 20° (68° Fah.); and as in this locality the cold was never below 23° Fah., the normal length $l$ of the wire was increased by a quantity $\rho$ equal to the sum of the contractions $\rho'$ and $\rho''$, which would be experienced by suspension cables for a lowering of 45° Fah. of temperature.

Now the value of $\rho'$ is given by the table B (26 observation) and is equal to $2 \times 0{\cdot}124 \text{ ft.} = 0{\cdot}248 \text{ ft.}$,

that of $\rho''$ is deduced from the relation:

$$\rho'' = l\,a\,t = 626{\cdot}62 \times {\cdot}00000518 \times 45 = 1{\cdot}48 \text{ ft.},$$

and therefore $\rho = \rho' + \rho'' = 0{\cdot}396 \text{ ft.}$

From the increased length, $\rho$, assigned to the standard wire was deduced the sagitta to be given it, that of the counter-cable having been fixed at 24·93 ft. for a temperature 68° Fah.

The general formula (1), in which we supposed

$$h = \frac{623{\cdot}35}{2} = 311{\cdot}67 \text{ ft. and } \gamma = \frac{\rho}{2} = 0{\cdot}198 \text{ ft.},$$

gives the increase of sagitta $\phi$, corresponding to the excess of length

ρ to be given the regulating wire, and so its definitive sagitta was equal to

$$24{\cdot}93 + 1{\cdot}83 = 26{\cdot}76 \text{ ft.}$$

*Effect produced by change of length of Counter-cables.*—It was thought that the small excess in length given to the counter-cable, would not sensibly change the figure of equilibrium, and that distributed over a development of 626 ft. it would not diminish the rigidity of the system. But this was not the case; the cable, when projected upon a vertical plane passing through longitudinal axis of bridge, followed a regular and continuous curve, but seen aside, the curve was changed, and each of the semi-arcs A C and C B assumed an inflected form, like a flat and elongated S.

This disagreeable effect was due to the marked double curvature necessarily taken from their inclination to the horizon and the excess of length it had been thought proper to give it. So serious an imperfection was not admissible, and care was taken to correct it.

For this purpose the primitive form of the cable was changed and the haunches were raised towards the platform, not only to absorb the excess of length, but to compensate by a small exaggeration of the curve of the central part of each semi-arc the appearances produced in an inverse direction, which otherwise would not have disappeared, since the double curvature is inevitable whatever may be the tension.

This change was effected by trials and by the simple displacement of the counter-cable rods, which were moved back 1, 2, or 3 rows towards the mooring points of the latter.

In these conditions the counter-cable, it is true, must more sensibly feel the effects of a lowering of temperature; but the strain arising from the momentary contraction in its length and that of the suspension cables will never exceed 21 lbs.; and as it will then be found very rigid, and so more effectively opposed to the vertical motions of the platform, there is no fear that this strain will be much increased by the present slight oscillations of the suspended system.

*Conclusions.*—The three prescribed operations of the administration have yielded the most satisfactory results.

The new galleries are effectually guarded against moisture and filtering water; they are well ventilated, easy of access, of suitable dimensions, and the mooring bundles are so arranged as to be easily maintained in all parts.

The establishment of the counter-cable has produced a remarkable stability in the system.

The vertical oscillations, whose amplitudes attained from 12 to 23½ ins. in high winds and 39 ins. in gales, are to-day insignificant. The greatest observed since the laying of the cable were below ⅜-in.

The diligence drawn by three horses at a gallop produces a scarcely appreciable effect; it is the same with ten mounted horses at a smart trot, or the march of thirty men.

The horizontal swinging of the platform is completely checked, and the permanent convexity of about 10 ins., which it formerly presented on the up-stream side, has wholly disappeared.

The presence of the supplementary and counter-cables have in no-

wise impaired the lightness, elegance, and harmony of the general construction.

A few observations are selected from the thirty referred to by the author, and given in the following table B, showing the changes in length of sagittæ of cables by the variations of temperature for Roche-Bernard bridge.

| Order of observations. | Dates of observations. | Temperature in degrees. Cent. | Fah. | Sagittæ observed. | Real variation of sagittæ | Variations in half length of cables deduced from those of sagittæ. | deduced from changes of temperature. | Observation. |
|---|---|---|---|---|---|---|---|---|
| | | ° | ° | m. | mm. | mm. | mm. | |
| 1 | Dec. 27, 1856, | + 2 | 36 | 14·81 | 0 050 | 0·010 | 0·013 | *b* |
| 3 | " 31, " | 0 | 32 | 14·795 | 0·030 | 0·006 | 0·009 | |
| 5 | Jan. 13, 1857, | + 6 | 43 | 14·820 | 0·060 | 0·012 | 0·021 | |
| 10 | " 29, " | — 4 | 25 | 14·800 | 0·040 | 0·008 | 0·002 | |
| 12 | Feb. 6, " | — 5 | 23 | 14·760 | 0·000 | 0·000 | 0·000 | |
| 14 | " 18, " | + 4 | 39 | 14·825 | 0·065 | 0 013 | 0·017 | |
| 17 | Mar. 7, " | — 1 | 30 | 14·805 | 0·045 | 0·009 | 0 008 | |
| 18 | " 11, " | + 6 | 43 | 14·820 | 0·060 | 0·012 | 0·021 | |
| 21 | May 4, " | +14 | 57 | 14·965 | 0·205 | 0·042 | 0·036 | |
| 23 | " 16, " | +20 | 68 | 14·97 | 0·210 | 0·042 | 0·047 | |
| 25 | July 14, " | +31 | 88 | 14·980 | 0·220 | 0·045 | 0·068 | |
| 28 | Aug. 12, " | +43 | 109 | 15 04 | 0 280 | 0·057 | 0·091 | |
| Totals | | 468 *a* | | | 3·405* | 0·689* | 0·885* | |

*a* This number represents the sum of variations referred to the point of departure — 5°.

*b* The variations in length start from the lowest observed sagitta 14·76 m.; and those of temperature are referred to — 5° of thermometer.

* These are sums averages of the 30 observations.

Correction.—In the March number, page 155, line 9,

$$\left(1 + \frac{2\,f^2}{2\,h^2}\right) \text{ should be } \left(1 + \frac{2\,f^2}{3\,h^2}\right).$$

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## *Observations on the Niagara Railway Suspension-Bridge.* By P. W. Barlow, C. E., F. R. S., &c.

From the London Builder, No. 927.

One of the most remarkable results from Mr. Barlow's personal and careful examination of the Niagara Railway Suspension-bridge is, that the favorable conclusions to which that examination has led, induced him to suggest the formation of two cross lines of suspension railway over the central districts of London, one commencing at the Elephant and Castle, and terminating near the Shoreditch station of the Eastern Counties Railway; and the other commencing at the junction of Oxford-street and Tottenham-court-road, and terminating at Whitechapel. Street-railways, he suggests, might converge from the outskirts to these lines. The cost of a wire suspension-girder viaduct, with a span of 1000 feet, would not, he estimates, exceed, for a double line of street omnibus traffic, £150,000 per mile. The only land re-

quired would be for the wrought iron towers, as a wire-bridge might be erected without the least interference with the intermediate property. Allowing £100,000 per acre (the average cost of the terminus of the South-Eastern Railway) for the land required, or £50,000 per mile, the whole scheme might, he calculates, be carried out for a little above £1,000,000. He further suggests the adoption of wire suspension-bridges where bridges have been long projected and abandoned from their cost and interference with property as hitherto proposed; and as an example he suggests the connexion of Holborn and Newgate-street by a suspension-bridge, thus avoiding Holborn-hill. A wire suspension-bridge, with towers of wrought iron, constructed like a vertical lattice beam, he urges, would offer little obstruction to the light, and would not exceed in cost the sum of £75,000. Mr. Barlow also proposes to connect Liverpool with Birkenhead by a wire suspension-bridge, 150 feet above the level of the river, at an estimated cost of £1,000,000, passengers to be raised to the level of the bridge at one end and lowered at the other by steam power. The span of this bridge would be no less than 3000 feet. He also proposes to suspend a similar bridge from New York to Brooklyn, with a span of 2000 feet.

The Niagara bridge, notwithstanding certain defects, Mr. Barlow is convinced, "is the safest and most durable railway bridge of large span which has been constructed:—first, because it is less liable to deterioration; and secondly, because the greatest strain to which it can be submitted is a less proportion of the ultimate strength of the supporting material."

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## *Steam Navigation on Canals.*

From the Journal of the Society of Arts, No. 422.

It is stated that the Grand Junction Canal Company have brought into use steam power for canal navigation, which if successful will materially reduce the cost of conveyance. The peculiar feature in the steamboats employed to ply between London and Birmingham or Manchester is a form of screw propeller, invented by Mr. Burch of Macclesfield. This "waggle tail" propeller is said to have the advantage of keeping all the disturbance of the water immediately behind the stern of the boat, instead of spreading it right and left, thus securing the canal banks from being damaged by the wash, and economizing the motive power. On Tuesday, the 18th inst., a party of gentlemen accompanied Mr. James Fulton, one of the company's officers, in a trip from the City Basin along the Regent's Canal to Paddington, a distance of five miles and three quarters, which was accomplished in an hour and a half, including the passage of five locks, and the Islington tunnel, half a mile long. The *Pioneer*, an ordinary fly-boat, 75 feet long by 7 feet extreme breadth, 25 tons burden, and drawing 2½ feet of water, with an engine of six-horse power, was the boat employed, towing another fly-boat which was laden with a general cargo to go to Wolverhampton. The two boats were able to go through the locks at once, floating side by side, and thus saving much delay. It is stated

that the *Pioneer*, when tried at Manchester, proved able to draw six loaded barges at once, with a total burden of no less than 300 tons. Four miles an hour, allowing for the locks and other hindrances, it is estimated will be the average rate of steam performance, instead of two miles an hour, the usual speed obtained by horse-towing. The steam-boat has stowage room for $2\frac{1}{2}$ tons of coal, which will carry her from London to Birmingham and half-way back, superseding the expensive relays of horses and drivers requisite for so long a journey. This water locomotive is estimated to be nearly 30 per cent. cheaper than railway carriage.

It may be observed that the aggregate amount of canal traffic, instead of diminishing, has increased since the construction of railways, and is now 25,000 tons more than it previously was. The total length of canals now open in Great Britain is about 5000 miles, including all the branch lines and junctions, and these works represent a capital of some forty millions.

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## MECHANICS, PHYSICS, AND CHEMISTRY.

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### *On the Chemical Constitution of Cast Iron and Steel.* By M. E. Fremy.

From the Lond. Chemical News, No. 49.

The interesting communication of Captain Caron* has furnished me with the occasion to make known to the Academy some of the results obtained in a research—which I have long pursued—into the constitution of cast iron and steel. The facts here stated have been already communicated to several Members of the Academy, and I have likewise alluded to them in my lectures at the Polytechnic School.

Numerous observations prove that nitrogen exercises an influence over the phenomenon of steeling, and confirms the opinion which our learned colleague, M. Despretz, has recorded in his work on Nitride of Iron.

Indeed, all chemists are aware of the rapid transformation of iron into steel under the influence of ferro-cyanide of potassium, and the interesting researches of M. Sanderson, in which this skilful manufacturer proves that in the cementation boxes steel is formed only under the double influence of carbon and nitrogen. I considered that in the process of cementation, the nitrogen not only presented the carbon in a gaseous state to the iron, but that, remaining united to the carbon, it could itself combine with the metal.

The presence of nitrogen in certain specimens of iron, cast iron, and steel, has been already recorded in the most precise manner by M. Marchand. It remained to discover under what state nitrogen could exist in steel or cast iron. This is the question I desire to examine.

In following the method of Berzelius, when steel or cast iron is submitted to the action of bi-chloride of copper, a residue containing graphite and a brown matter is obtained. This last substance is not

*Chemical News, Vol. II, p. 243.

carbon, as is generally believed; it is partly soluble in potash. When heated, it disengages a considerable quantity of ammonia, and shows an analogy with certain derivatives of cyanogen. Experiments (which I shall make known in a special Memoir) tend to prove that cast iron and steel, hitherto considered as carbides of iron, are rather combinations of metal with a compound radical, comparable to cyanogen, and which, like it, is produced directly by combination of carbon with atmospheric nitrogen. The brown matter before alluded to, and the empyreumatic oil formed during the action of acids on cast iron and steel, will be the products of the decomposition of this compound radical.

The metalloids, such as sulphur, phosphorus, and arsenic, which modify so remarkably the properties of steel and cast iron, act, in my opinion, principally on the nitrogen compound of which I have just spoken, and can even modify it by substitution. On this point I shall adduce an experiment which appears to me interesting in a theoretical point of view, and which explains some facts observed in practice.

A specimen of cast iron, rich in graphite, prepared with wood charcoal, was melted in the middle of a siliceous slag. The ingot thus obtained was covered with graphite, and the casting, charged during the operation with three per cent. of silicium, remained grey and malleable. It consequently resembled the grey cast iron prepared with coke under favorable conditions. Silicium was substituted in this case for carbon, which, crystallizing to the state of graphite in the metallic mass, formed the grey siliceous cast iron so well known to metallurgists. The same grey cast iron was then submitted to the action of various slags, so as to impart sulphur, phosphorus, or arsenic to the metal. In these trials, the cast iron became white, and the metalloids were substituted for the carbon, which being completely eliminated from the metallic bath, crystallized on the surface into large plates of graphite. These specimens of cast iron treated by acids, produced the empyreumatic oils which contained the metalloids employed to whiten the cast iron.

When sulphur is introduced into cast iron, it expels a part of the carbon, and forms a sulphuretted radical, producing a white cast iron no longer possessing the property of incorporating itself with graphite, like the ordinary grey cast iron.

By studying the modifications produced by metalloids on the organic substance contained in cast iron, fine metal, and steel, the relation between these products is determined. For this purpose, the existing chemical analyses are inadequate; indeed, the analytical notions bearing upon the crude determination of carbon contained in cast iron and steel, furnish no useful indication, for, in general, the name of carbon is given to a mixture of graphite and an organic nitrogenous substance; account is also taken of the graphite, which is simply interposed in the metallic mass, and plays no part whatever, while the determination of the nitrogenous substance, which appears to be the really active body, is neglected.

Upon the whole, it appears to me at the present time impossible to

admit that cast iron, fine metal, and steel, are formed essentially by the combination of iron with carbon, and that the difference between them is due simply to the proportion of this metalloid present. The substance which in the preceding compounds modifies the properties of iron so usefully for the arts, may be sometimes a metalloid, and also sometimes a compound; it is then allied to the derivatives of cyanogen, and, like them, is transformed by the action of metalloids; when this substance contains either nitrogen, sulphur, phosphorus, or arsenic, it forms, when united with iron, cast iron, either white, or grey and spotted, fine metal, and steel.

The color and appearance of the castings are not sufficient, then, to determine their composition; there are several kinds of white castings, which differ from one another according to the nature of the metalloid they contain; a grey casting, prepared with coke holding two or three per cent. of silicium, may resemble another grey specimen prepared with wood, which is scarcely siliceous. The relations which connect cast iron and steel are not so simple as is generally believed.

At a period when it is required to produce steel at a low price, and various methods are in operation for converting cast iron into steel, it appears to me that the preceding facts may guide iron-masters in their experiments, especially in determining the nature of the problem to be solved.—*Comptes-Rendus.*

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## *Density of Absolute Alcohol, and its Mixtures with Water. Correction.*

In our Journal for 1860 (3d ser. vol. XI, p. 268), we published the table of results of M. Baumhauer upon the specific gravities of alcohol and its mixtures, together with his assertion that his numbers were totally different from those of Lowitz and Gay-Lussac. It now appears that in this assertion, M. Baumhauer was totally mistaken; and that when all the conditions of the experiments are taken into consideration, his numbers furnish a very remarkable confirmation of those of Gay-Lussac and of Gilpin; the greatest difference between Gay-Lussac and himself being 0·0003; the mean of 16 sets of experiments, 0·00014; between Gilpin and Baumhauer, maximum difference = 0·0006; mean difference of 18 sets of experiments = 0·00016. This result will give great additional confidence in our usual tables, which are founded on the experiments of Gay-Lussac and Gilpin.

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## *Silver Test.*

Silver coins, jewelry, or any other rich alloy, when moistened with a solution of chromic acid, or a mixture of bi-chromate of potassa and sulphuric acid, become covered with a red-purple spot of bi-chromate of silver. This spot does not occur on poor alloys or metals imitating silver.—*Cosmos*, September, 1860.

For the Journal of the Franklin Institute.

*Strength of Materials:* Deduced from the latest experiments of Barlow, Buchanan, Fairbairn, Hodgkinson, Stephenson, Major Wade, U. S. Ordnance Corps, and others. By CHAS. H. HASWELL, Civil and Marine Engineer.

No. 6.

(Continued from page 192.)

CRUSHING STRENGTH.

The Crushing Strength of any body is in proportion to the area of its section, and inversely as its height.

Experiments upon cast iron bars, give a crushing stress of 5000 lbs. per square inch of section, as just sufficient to overcome the elasticity of the metal, and when the height exceeds three times the diameter, the iron yields by bending.

When the height of a prism or column is not 5 times its side or diameter, the crushing strength is at its maximum.

| | | | | |
|---|---|---|---|---|
| When it is | 10 times it is reduced as | | 1·75 | to 1. |
| | 15 " | " | 2· | to 1. |
| | 20 " | " | 3· | to 1. |
| | 30 " | " | 4· | to 1. |
| | 40 " | " | 6· | to 1. |

In tapered columns, the strength is determined by the least diameter.

The experiments of Mr. Hodgkinson have determined,—

The resistance to fracture from flexure in long columns of like dimensions, is about three times greater when the ends of the columns are flat and firmly bedded, than when they are rounded and capable of being diverted from their vertical position.

An increase of strength of about $\frac{1}{7}$th to $\frac{1}{8}$th of the breaking weight is obtained by enlarging the diameter of a column in its middle.

In cast iron columns of the same thickness, the strength is inversely proportional to the 1·7 power of the length, nearly. Thus, In solid columns, the ends being flat, the strength is as $\frac{d^{3\cdot6}}{l^{1\cdot7}}$, *l representing the length*, and *d, the diameter.*

In hollow columns having a greater diameter at one end than the other, or in the middle than at the ends, it was not found that any additional strength was obtained over that of uniform cylindrical columns.

The strength of a column in the form of that of a connecting rod of an engine, was found to be very low: being less than half the strength that the same metal would have given if cast in the form of a uniform hollow cylinder. The ratio being as 175 to 396.

The strength of a column irregularly set, the pressure being in the direction of its diagonal, is reduced to one-third of its strength when the pressure is vertical.

In rectangular columns, the length and quality of the material being the same, the square gives the highest strength.

With cast iron, a pressure beyond 12 tons per square inch is of little if any use, in practice.

For equal decrements of length, wrought iron will sustain double the pressure of cast iron.

Glass and the hardest stones have a crushing strength from seven to nine times greater than tensile; *hence*, an approximate value of their crushing strength may be obtained from their tensile and contrariwise.

A hollow column of cast iron, 10 inches in diameter, and but $\frac{3}{4}$ inch thick, may be extended to 12·5 feet in height, and possess the same resistance as a solid column of like weight, 6·5 inches in diameter, and but 7·5 feet in height.

TABLE OF THE CRUSHING STRENGTH OF VARIOUS MATERIALS.

Deduced from the Experiments of Major Wade, Hodgkinson, and Capt. Meigs, U.S.A., and reduced to an uniform measure of

*One Square Inch.*

| FIGURES AND MATERIAL. | Side or diameter. | Height. | Crushing weight. |
|---|---|---|---|
| CAST IRON PRISMS. | Ins. | Ins. | lbs. |
| American, gun metal | ·6 | 1·5 | 147,803 |
| mean | ·6 | 1·5 | 129,000 |
| English, Low Moor, No. 1 | 1· | 1· | 62,450 |
| do do | 1·25 | 2· | 63,640 |
| do No. 2 | ·75 | 1·5 | 92,330 |
| Clyde, No. 3 | ·75 | 1·5 | 106,039 |
| Calder No. 3 | ·75 | 1·5 | 101,000 |
| Stirling* No. 2 | ·75 | 1·5 | 119,550 |
| Mean of all, | ·75 | 1·5 | 122,395 |
| Extreme, | 1· | 1·5 | 134,400 |
| WROUGHT IRON PRISMS. | | | |
| American, mean | 1· | 1· | 83,500 |
| English, | 1· | 1·875 | 65,200 |
| METAL PRISMS. | | | |
| Fine Brass, | 1· | 1· | 164,800 |
| Cast Copper, | 1· | 1· | 117,000 |
| Wrought do., | 1· | 1· | 103,000 |
| Cast Tin, | 1· | 1· | 15,500 |
| Lead, | 1· | 1· | 7,730 |
| CAST STEEL. | | | |
| Soft, | | | 198,944 |
| Tempered, | | | 373,041 |
| do. mean | | | 295,000 |
| Tungsten, | | | 155,916 |

*Cast and Wrought Iron mixed.

| Wrought Iron. | Width. | Thickness. | Area. | |
|---|---|---|---|---|
| **Plates.** | Ins. | Ins. | Ins. | |
| Length, 10 feet, . | 2·98 | ·497 | 1·48 | 815 |
| 10 " . | 3·01 | ·766 | 2·30 | 3,379 |
| 7 " 6 inches, . | 1·02 | 1·025 | 1·05 | 9,752 |
| 5 " . | 1·02 | 1·024 | 1·05 | 17,267 |
| 2 " 6 " . | 1·02 | 1·024 | 1·05 | 25,327 |
| 1 " 3 " . | 1·02 | 1·023 | 1·05 | 34,555 |
| **Hollow Cylinders.** | External. | Internal. | | |
| Length, 9 feet 11 inches, . | 1·495 | 1·292 | ·444 | 14,661 |
| 9 " 11 " . | 2·49 | 2·275 | ·804 | 29,779 |
| 10 . . | 2·34 | 1·91 | 1·435 | 22,179 |
| 10 . | 6·366 | 6·106 | 2·547 | 35,886 |
| **Rectangular Tubes.** | | | | |
| Length, 10 feet, lap riveted, | 4·1 | 4·1 | ·504 | 10,980 |
| 10 " lap riveted, | 4·1 | 4·1 | 1·020 | 19,261 |
| 10 " lap riveted, | 4·25 | 4·25 | 2·395 | 21,585 |
| 10 " lap riveted, | 8·4 | 4·25 | 6·890 | 29,981 |
| 10 " lap riveted, | 8·1 | 8·1 | 2·070 | 132,76 |
| 10 " lap riveted, and with two internal diaphragm plates, . . | 8·1 | 8·1 | 3·551 | 19,800 |

| Cast Iron. | Diameter. | Height. | Crushing weight. |
|---|---|---|---|
| **Solid Cylinders.** | Ins. | Ins. | lbs. |
| English, Low Moor, No. 3, Dry sand, | ·5 | 60·5 | 730 |
| " " Dry sand, | 1· | 60·5 | 2,423 |
| " " Dry sand, | 1·96 | 60·5 | 8,097 |
| " " Green sand, | ·5 | 60·5 | 2,485 |
| " " Green sand, | 1· | 60·5 | 8,061 |
| " " Green sand, | ·51 | 20·16 | 1,914 |
| " " Green sand, | ·5 | 12·1 | 3,595 |
| " " Green sand, | ·52 | 2· | 11,433 |
| " " Green sand, | ·52 | 1· | 12,308 |
| **Hollow Cylinders.** | External diameter. | Internal diameter. | |
| English, Low Moor, No. 3. Height, 7 feet 6·75 inches. Dry sand, . | 1·75 | 1·21 | 31,298 |
| | 1·99 | 1·31 | 39,804 |
| | 2·23 | 1·54 | 58,796 |
| **Woods.** | Diameter. | Height. | |
| Oak, American . . | 1 | 1 | 4,100 |
| Canadian . . | 1 | 2 | 5,982 |
| English . . . | 1 | 2 | 9,500<br>6,484 |
| Yellow Pine, . . | 1 | 2 | 5,375 |
| Ash, . . . | 1 | 2 | 8,663 |
| Beech, . . . | 1 | 2 | 9,363 |
| Cedar, . . . | 1 | 2 | 5,768 |
| Elm, . . . | 1 | 2 | 10,331 |
| Box, . . . | 1 | 2 | 9,265 |

| MATERIAL. | Diameter. | Height. | Crushing weight. |
|---|---|---|---|
| WOODS (Continued). | Ins. | Ins. | lbs. |
| Mahogany, Spanish . . | 1 | 2 | 8,198 |
| Sycamore, . . | 1 | 2 | 7,082 |
| Walnut, . . . | 1 | 2 | 6,645 |
| Teak, . . . | | | 12,100 |
| STONES, &c. | | | |
| Granite, Patapsco . . | 1 | 1 | 11,200 |
| Sandstone, Aquia Creek* . | 1 | 1 | 5,340 |
| Seneca† . . | 1 | 1 | 10,764 |
| Aquia Creek, strata laid horizontally, | 1 | 1 | 8,332 |
| Marble, Stockbridge‡ . . | 1 | 1 | 10,382 |
| East Chester§ . . | 1 | 1 | 23,917 |
| Symington, large crystals,‖ . | 1 | 1 | 11,156 |
| Same, strata horizontal, . | 1 | 1 | 10,124 |
| Same, strata vertical, . | 1 | 1 | 9,124 |
| Same, fine crystal, . . | 1 | 1 | 18,248 |
| Italian . . | 1 | 1 | 12,624 |
| Lee, Mass., . . | 1 | 1 | 22,702 |
| Hastings, N. Y., . | 1 | 1 | 18,941 |
| Montgomery co., Penna., . | 1 | 1 | 8,950 |
| Baltimore, large crystal, . | 1 | 1 | 8,057 |
| do small crystal, . | 1 | 1 | 18.061 |
| Freestone, Belleville . . | 1 | 1 | 3,522 |
| Connecticut . . | 1 | 1 | 3,319 |
| Dorchester . . | 1 | 1 | 3,059 |
| Little Falls . . | 1 | 1 | 2,991 |
| Caen . . | 1 | 1 | 1,088 |
| Gneiss, . . . | 1 | 1 | 19,680 |
| Brick, hard . . | 1 | 1 | { 4,368<br>2,000 |
| Common . . | 1 | 1 | { 4,000<br>800 |
| English Craigleith Limestone, . | 1 | 1 | 5,600 |
| " Sandstone, . | 1 | 1 | 31,449 |
| Arbroath, . . | 1 | 1 | 7,884 |
| Stone, . . | 1 | 1 | 8,270 |
| Caithness, . . | 1 | 1 | 6,493 |
| Portland, . . | 1 | 1 | { 15,583<br>4,570 |
| Aberdeen granite, . | 1 | 1 | { 8,400<br>10,363 |
| Portland oolite, . . | 1 | 1 | 3,850 |
| Limestone, . . | 1 | 1 | 3,065 |
| Portland cement, mean, . | 1 | 1 | 8,300 |
| Adelaide Sandstone, . . | 1 | 1 | 2,800 |
| Sydney " . . | 1 | 1 | 2,228 |
| Normandy Caen, . . | 1 | 1 | 1,543 |
| Portland Cement 1, Sand 2, . . | 1 | 1 | 8,400 |
| " 1, " 3, . | 1 | 1 | 5,000 |
| " 1, " 4, . . | 1 | 1 | 5,900 |
| " 1, " 6, . | 1 | 1 | 8,400 |
| Fire Brick, English, . . | 1 | 1 | 2,442 |
| " Stourbridge, . | 1 | 1 | 1,717 |
| Stock " . . . | 1 | 1 | 2,177 |
| Red " . . . | 1 | 1 | 807 |
| Marble, . . . | 1 | 1 | 6,431 |

* Same as that of the Capitol, Treasury Department, and Patent Office, Washington, D. C.
† " Smithsonian Institute. ‡ Same as that of the City Hall, New York.
§ " General Post Office, Washington. ‖ " National Wash. Monum't.

COMPARATIVE STRENGTH OF CAST AND WROUGHT IRON TO BEAR COMPRESSION IN THE DIRECTION OF THEIR LENGTH.

Dimensions of Bar, 1 inch square, and 10 feet in length.

*Decrease in Length.*

| Weight. | Cast Iron. | Wrought Iron. | Weight. | Cast Iron. | Wrought Iron. |
|---|---|---|---|---|---|
| lbs. | Ins. | Ins. | lbs. | Ins. | Ins. |
| 5,054 | ·054 | ·028 | 27,498 | ·300 | ·143 |
| 9,578 | ·102 | ·052 | 29,738 | | ·151 |
| 11,818 | ·126 | | 31,978 | ·357 | ·174 |
| 14,058 | ·151 | ·073 | 40,938 | ·503 | |
| 23,018 | ·247 | ·119 | 54,378 | ·865 | |

RESISTANCE OF CAST AND WROUGHT IRON BARS TO COMPRESSION, LAID VERTICALLY.

*One Inch Square, and Ten Feet in Length, enclosed in an iron frame to maintain them in a vertical position.*

CAST IRON.

| Iron. | Weight applied. | Extension. | Set. |
|---|---|---|---|
| | lbs. | Ins. | Ins. |
| Low Moor, No. 2, . . | 2,100 | ·0230 | ·00100 |
| | 4,200 | ·0442 | ·00325 |
| | 8,401 | ·0884 | ·00862 |
| | 16,802 | ·1773 | ·02125 |
| | 33,604 | ·3810 | ·07262 |
| Blaenarvon, No. 2, . | 2,032 | ·0191 | |
| | 4,064 | ·0391 | ·00187 |
| | 8,125 | ·0791 | ·00483 |
| | 16,257 | ·1618 | ·01775 |
| | 32,514 | ·3139 | ·06270 |
| Mean of four kinds, . . | 2,064 | ·0187 | ·00047 |
| | 4,129 | ·0388 | ·00226 |
| | 8,258 | ·0788 | ·00645 |
| | 16,517 | ·1634 | ·01712 |
| | 33,030 | ·3534 | ·06096 |

WROUGHT IRON.

*Ultimate Practical Resistance.*

Mean weight, 26,933 lbs. Mean compression, ·139 inches.

*Hence*, the length of the bars being 10 feet = 120 inches, $\frac{120}{\cdot 139} = 863$; consequently, a wrought iron bar will bear a compression of $\frac{1}{863}$ of its length, without its utility being destroyed, although its elasticity will be materially injured.

*To Ascertain the Crushing Strength of a Solid Cylindrical Column of Cast Iron.*

$\frac{d^{3\cdot 6}}{l^{1\cdot 7}} \times 100000 = \text{W}$. *d representing the diameter of the column in inches. l, its length in feet, and* W *the crushing weight.*

EXAMPLE.—What is the resistance to crushing of a solid cylinder, 2 inches in diameter and 5 ft. in length?

$$\frac{2^{3\cdot6}}{5^{1\cdot7}} = \frac{12\cdot125}{15\cdot426} \times 100000 = 78601 \text{ lbs.}$$

*To Ascertain the Crushing Strength of a Hollow Cylindrical Column of Cast Iron.*

$\frac{D^{3\cdot6} - d^{3\cdot6}}{l^{1\cdot7}} \times 100000 = W.$ D *representing the greater diameter.*

EXAMPLE.—What is the resistance to crushing of a hollow cylindrical column having diameters of 2 and 1·25 inches and a length of 7 feet?

$\frac{2^{3\cdot6} - 1\cdot25^{3\cdot6}}{7^{1\cdot7}} = \frac{12\cdot125 - 2\cdot233}{27\cdot332}$ which, $\times\ 100000 = 36190.$

The above formulæ are those of Hodgkinson for the breaking or crushing weight. The formulæ of Euler, which are for the incipient breaking weight, are preferable and are with the alteration of the coefficient, thus: $\frac{d^4}{l^2} \times 100000 = W$ for solid cylinders, and $\frac{D^4 - d^4}{l^2} \times 100000 = W$ for hollow cylinders.

The safe load that may be borne by a column of cast iron, independent of any considerations, regarding the operation of its ends as to their being square or not, or flat, or rounded, &c., is from 5000 to 8000 lbs. per square inch for short or stable bodies.

NOTE.—The above formulæ apply to all columns where the length is not less than about 30 times the external diameter; for columns shorter than this, a modification of the formulæ is necessary, as in shorter columns the breaking weight is a large portion of that necessary to crush the column.

Thus: A column has two functions; one to support weight and the other to resist flexure; it follows, then, that when the pressure necessary to break the column is very low on account of the extreme length of it compared with its diameter or depth, then the strength of the whole transverse section of the column will be exerted in resisting flexure. When the breaking pressure is half of what would be required to crush the material, one-half only of the resistance may be considered as available to resist flexure, the other half being exerted in crushing, but when, through the shortness of the column, the breaking weight is so great as to be nearly equal to the crushing force, a very little, if any, portion of the resistance or strength of the column is applied or exerted in resisting flexure.

*To Ascertain the Weight that may be safely borne by Columns of Various Dimensions and Materials.*

RECTANGULAR COLUMNS.

CAST IRON.— $\frac{16000\, l b^3}{4\, b^2 + \cdot18\, l^2} = W.$

WROUGHT IRON.— $\frac{18000\,l\,b^3}{4\,b^2 + \cdot16\,l^2} = \text{W}.$

OAK.— $\frac{4000\,l\,b^2}{4\,b^2 + \cdot5\,l^2} = \text{W}.$

### SOLID CYLINDERS.

CAST IRON.— $\frac{10000\,d^4}{4\,d^2 + \cdot18\,l^2} = \text{W}.$

WROUGHT IRON.— $\frac{11200\,d^4}{4\,d^2 + \cdot16\,l^2} = \text{W}.$

OAK.— $\frac{2500\,d^4}{4\,d^2 + \cdot5\,l^2} = \text{W}.$

### HOLLOW CYLINDERS.

CAST IRON.— $\frac{16000\,\text{D}^4 - d^4}{4\,\text{D}^2 + \cdot18\,l^2} = \text{W}.$

WROUGHT IRON.— $\frac{11200\,\text{D}^4 - d^4}{4\,\text{D}^2 + \cdot16\,l^2} = \text{W}.$

OAK.— $\frac{2500\,\text{D}^4 - d^4}{4\,\text{D}^2 + \cdot5\,l^2} = \text{W}.$

*l representing the length in feet, b the breadth, and* D *and d the diameter in inches, and* W *the weight in pounds.*

EXAMPLE.—What are the crushing weights that may be safely borne by a cast iron, wrought iron, and oak rectangular column 2 ins. square and 5 feet in height?

$$\frac{16000 \times 5 \times 2^3}{4 \times 2^2 + (\cdot18 \times 5^2)} = \frac{16000 \times 5 \times 8}{32 + 4\cdot5} = 17534 \textit{ lbs.}$$

for the cast iron.

$$\frac{18000 \times 5 \times 2^3}{4 \times 2^2 + (\cdot16 \times 5^2)} = \frac{18000 \times 5 \times 8}{32 + 4} = 20000 \textit{ lbs.}$$

for the wrought iron.

$$\frac{4000 \times 5 \times 2^3}{4 \times 2^2 + (\cdot5 \times 5^2)} = \frac{4000 \times 5 \times 8}{32 + 12\cdot5} = 3596 \textit{ lbs.}$$

for the oak.

TABLE *showing the Weight or Pressure a Column of Cast Iron will Sustain with safety.*

| | Length or Height in Feet. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 |
| Inch. | | | | | | | | | |
| 2·5 | 13,923 | 12,285 | 10,647 | 9,009 | 7,605 | 6,435 | 5,499 | 4,680 | 3,978 |
| 3· | 20,826 | 19,071 | 16,965 | 14,976 | 12,987 | 11,349 | 9,828 | 8,541 | 7,488 |
| 3·5 | 28,899 | 27,144 | 25,038 | 22,347 | 20,124 | 18,252 | 15,975 | 13,923 | 12,402 |
| 4· | 38,142 | 36,270 | 33,696 | 31,122 | 28,314 | 25,740 | 23,166 | 20,826 | 18,720 |
| 4·5 | 48,906 | 46,800 | 44,343 | 41,418 | 38,259 | 35,217 | 32,175 | 29,367 | 26,793 |
| 5· | 61,074 | 58,617 | 56,043 | 52,884 | 49,959 | 46,098 | 42,705 | 39,439 | 36,270 |
| 6· | 71,019 | 69,261 | 67,041 | 64,350 | 61,425 | 58,149 | 54,873 | 51,480 | 48,321 |
| 7· | 120,744 | 118,521 | 115,713 | 112,203 | 108,108 | 103,779 | 99,216 | 94,536 | 89,505 |
| 8· | 155,961 | 153,855 | 150,813 | 147,303 | 143,208 | 138,645 | 133,614 | 128,349 | 123,084 |
| 9· | 200,772 | 198,549 | 195,624 | 191,880 | 187,551 | 182,637 | 177,255 | 171,639 | 165,672 |
| 10· | 247,923 | 245,700 | 243,009 | 239,265 | 234,819 | 229,788 | 224,172 | 218,205 | 211,887 |
| 11· | 300,690 | 298,350 | 294,840 | 291,330 | 286,650 | 281,970 | 275,886 | 269,685 | 263,016 |
| 12· | 356,850 | 355,680 | 353,340 | 347,490 | 342,810 | 339,300 | 331,110 | 325,260 | 319,410 |

TABLE *Exhibiting the Relative Value of Various Woods, their Crushing Strength and Stiffness being combined.*

| | | | |
|---|---|---|---|
| Teak, | 6,555 | American Spruce, | 2,522 |
| English Oak, | 4,074 | Walnut, | 2,378 |
| Ash, | 3,571 | Yellow Pine, | 2,193 |
| Elm, | 3,468 | Larch, | 1,897 |
| Beech, | 3,079 | Sycamore, | 1,833 |
| Quebec Oak, | 2,927 | Poplar, | 975 |
| Spanish Mahogany, | 2,571 | Cedar, | 700 |

*Comparative Strength of Long Columns of Various Materials.*

| | | | |
|---|---|---|---|
| Cast Iron, | 1,000 | Oak, | 108·8 |
| Wrought Iron. | 1,745 | Pine, | 78·5 |
| Cast Steel, | 2,518 | | |

RESULTS OF EXPERIMENTS

To determine the Resistance of Rectangular and Cylindrical Tubes of Wrought Iron to a Crushing Force applied horizontally in the direction of their length.

| Length of tubes. | | External dimensions. | Thickness of metal. | Weight of greatest resistance. | Area of section. | Weight per sq. inch of greatest resistance. | Weight per sq. inch at which deflection was observed. |
|---|---|---|---|---|---|---|---|
| RECTANGULAR. | | | | | | | |
| Ft. | ins. | Ins. | Ins. | lbs. | Sq. ins. | lbs. | lbs. |
| 10 | | 4·1 × 4·1 | ·03 | 5,534 | ·504 | 10,980 | |
| 5 | | " | " | 5,803 | " | 11,514 | |
| 2 | 6 | " | " | 6,251 | " | 12,403 | |
| 10 | | 4·25 × 4·25 | ·134 | 51,690 | 2·395 | 21,585 | 46,314 |
| 10 | | 8·4 × 4·25 | ·26 × ·126* | 206,571 | 6·89 | 29,981 | 99,916 |
| 10 | | 8·5 × 8·375 | ·2191 | 198,955 | 7·7367 | 25,716 | |
| CYLINDRICAL. | | | | | | | |
| | | | Internal diameter. | | | | |
| 9 | 11 | 1·495 | 1·292 | 6,514 | ·4443 | 14,661 | |
| 5 | | " | " | 13,860 | " | 31,195 | |
| 2 | 6 | " | " | 15,204 | " | 34,221 | |
| 9 | 11 | 2·995 | 2·693 | 37,350 | 1·349 | 27,691 | |
| 2 | 4 | 3· | 2·712 | 52,874 | 1·414 | 37,393 | |
| 5 | | 3·995 | 3·504 | 86,922 | 2·895 | 30,025 | |
| 5 | | 3 995 | 3·513 | 98,122 | 2·848 | 34,453 | |
| 2 | 4 | 4· | 3·5 | 136,202 | " | 47,823 | |

* Greatest thickness and least depth laid horizontally.

## BRIDGES.

Iron bridges with a circular arc, should have a rise of ·1 of the chord line, and a width of pier of ·1 of span.

*Girders combined with Suspension Chains* (P. W. Barlow).

In a suspended girder, the stress is resisted by back chains or wire rope.

A suspension girder designed for the Londonderry bridge, was rendered equally rigid with a simple girder with less than $\frac{1}{25}$th of the

metal required in the girder above, and from experiments upon a model of the bridge, it was deduced that the deflection of one of the girders when suspended was about $\frac{1}{25}$th of that when the suspension was detached; and, as the girder in the experiment was only suspended at one point, this deflection would be further reduced by suspension at several points, as in the bridge itself.

In suspension bridges, it is essential that the platform should be made as rigid as practicable, to arrest vertical undulations.

The economy of metal in a suspension bridge under the average circumstances of its attainable depth, is from one-fourth to one-half of that in a tubular or simple girder bridge of equal strength and rigidity.

*Comparison between the Two Largest Railway Bridges yet constructed.*

Niagara—Wire. Having a roadway, and a single railway of three gauges in a span of 820 feet; weighs 1000 tons.

Britannia—Tubular. Having a double line of railway in a span of 460 feet; weighs 3000 tons.

### Trussed Beams or Girders.

Wrought and cast iron possess different powers of resistance to tension and compression, or have different tensile and crushing strengths; and when a beam is so constructed that these two materials act in unison with each other *at the stress due to the load required to be borne*, their construction will effect an essential saving of material.

In consequence of the difficulty of adjusting a tension rod to the strain required to be resisted, it is held to be impracticable to construct a perfect truss beam; for, if too high a tension is given to the rod or rods, they will part before the beam has been strained to its yielding point, and, on the contrary, if too low a tension is given to them, the beam will break before it has been strained to its yielding point.

Fairbairn declares that it is better for the tension of the truss rod or rods to be low than high, which position is fully supported by the following elements of the two metals:—

*Wrought iron* has great tensile strength, and, having great ductility, it undergoes much elongation when acted on by a tensile force. On the contrary, *cast iron* has great crushing strength, and, having but little ductility, it undergoes but little elongation when acted on by a tensile force; and, when these metals are released from the action of a high tensile force, the *set* of the one differs widely from that of the other, that of the wrought iron being the greatest. Under the same increase of temperature, the expansion of wrought is considerably greater than that of cast iron; 1·81* tons per square inch is required to produce in wrought iron the same extension as in cast iron by 1 ton.

* The elongation of cast and wrought iron being 5500 and 10,000; *hence*, 10,000 ÷ 5500 = 1·81. Fairbairn, in treating of English metals, gives the elongation as 5450 and 12,300; *hence*, 12,300 ÷ 5450 = 2·25.

The relative tensile strengths of cast and wrought iron being as 1 to 3, and their resistance to extension as 1 to 1·81, therefore, where no initial tension is applied to a truss rod, the cast iron must be ruptured before the wrought iron is sensibly extended.

Fairbairn, in his experiments upon English metals, shows that with a strain of about 12,320 lbs. per square inch on cast iron, and 28,000 lbs. on wrought iron, the sets and elongations are nearly equal to each other; and for strains below 12,320 lbs. and 28,000 lbs., the set of cast iron is greater than that of wrought iron, and for strains above these, the set of wrought iron is the greatest.

From other experiments, he deduced that within the limits of strain of 13,440 lbs. per square inch for cast iron, and 30,240 lbs. per square inch for wrought iron, the tensile force applied to wrought iron must be 2·25 times the tensile force applied to cast iron, to produce equal elongations.

The resistance of the cast iron in a trussed beam is not wholly that of tensile strength, but it is a combination of both tensile and crushing strengths, or a transverse strength; *hence*, in estimating the resistance of a girder, the transverse strength of it is to be used in connexion with the tensile strength of the truss.

The mean practical transverse strength of a cast iron bar, one inch square and one foot in length, supported at both ends, the strain applied in the middle, is about 900 lbs.; and as the mean practical tensile strength of wrought iron is about 20,000 lbs. per square inch, the ratio between the sections of the beams and of the truss, should be in the ratio of the transverse strength per square inch of the beam and of the tensile strength of the truss.

The girders under consideration are those alone in which the truss is attached to the beam at its lower flanch, in which case it presents the following conditions:—

1. *When the truss runs parallel to the lower flanch.*

2. *When the truss runs at an inclination to the lower flanch, being depressed below its centre.*

3. *When the beam is arched upwards, and the truss runs as a chord to the curve.*

Consequently, in all these cases the section of the beam is that of an open one with a cast iron upper flanch and web, and a wrought iron lower flanch, increased in its resistance over a wholly cast iron beam, in proportion to the increased tensile strength of wrought iron over cast iron for equal sections of metals.

As the deductions of Fairbairn as to the initial strain proper to be given to the truss are based upon a cast iron beam with the truss inserted with the upper flanch of the beam, whereby it was submitted almost wholly to a tensile strain; they will not apply to the two constructions of trussed beams under consideration. As each construction of trussed beam will produce a strain upon the truss in accordance with the position of the neutral axis of the section of the whole beam, and as the extension of the truss will vary according as it is

more or less ductile; it is impracticable in the absence of the necessary elements to give an amount of initial strain that would be applicable as a rule.

From the various experiments made on trussed beams, it is shown:

1. That their rigidity far exceeds that of simple beams; in some cases, it was from 7 to 8 times greater.

2. That when the truss resists rupture, the upper flanch of the beam being broken by compression, there is a great gain in strength.

3. That their strength is greatly increased by the upper flanch being made larger than the lower one.

4. That their strength is greater than that of a wrought iron tubular beam, containing the same area of metal.

(To be Continued.)

## *Census of France.*

The following interesting table is taken from the *Cosmos*, and gives the comparative number of inhabitants in France in 1851 and 1856, with their means of support:

| | 1851. | 1856. |
|---|---|---|
| Agriculture, | 21,992,874 | 19,061,071 |
| Arts and Commerce, | 9,233,895 | 12,202,391 |
| Liberal Professions, | 3,483,538 | 3,262,282 |
| Without Profession, | 1,022,063 | 1,483,925 |
| | 35,732,370 | 36,009,669 |

## *Relations between the Densities and Atomic Weight of the different varieties of Carbon.* By L. Playfair.

It is known that (calling $d$ the density of a simple body; $p$, the atomic weight; $v$, the atomic volume) we have $\frac{p}{d} = v$. On the other hand, the densities of carbon are, from the average of the determinations: in the state of the diamond, 3·46; graphite, 2·29; charcoal, 1·88. Substituting these values for $d$, and remarking that the equivalent of carbon in its three forms is essentially the same, and equal to 12, we find for the atomic volume in these three states: diamond, 3·46; graphite, 5·24; charcoal, 6·38. But we also have $\sqrt{12} = 3{\cdot}364$; $\sqrt[3]{12} = 2{\cdot}289$; $\sqrt[4]{12} = 1{\cdot}865$.

Whence Mr. Playfair concludes that if we square the density of the diamond, cube that of graphite, and raise that of charcoal to the fourth power, we get sensibly the same number 12. That is to say, calling these three densities $d$, $d'$, and $d''$, we have sensibly, $d^2 = 12$; $d'^3 = 12$; and $d''^4 = 12$, and consequently,

$$d' = \sqrt[3]{d^2} = d^{\frac{2}{3}}; \; d'' = \sqrt[4]{d^2} = d^{\frac{1}{2}}.$$

*Cosmos*, Jan., 1861, p. 37.

Translated for the Journal of the Franklin Institute.

*Silvering Mirrors.* Process of MM. Brossette & Co. Patented in France, 1855.—*Report of the Committee of the Society for the Encouragement of National Industry of France.*

After the surface of the glass to be silvered has been cleaned with Spanish whiting and water, it is rubbed over with jeweller's putty (oxide of tin), with some ammonial nitrate of silver added to it; this is the same salt which is afterwards used in the silvering.

Before proceeding to silver, the glass as it lies on its supports, is washed with a caoutchouc roller soaked in distilled water, and then placed truly horizontally on a cast iron table covered with oil-cloth, which forms the upper part of a rectangular trough filled with water whose temperature is raised to 60° Cent. (140° Fah.) by means of steam. When this has been done, there is poured upon the glass a solution 100 parts by weight of nitrate of silver dissolved in 500 parts of distilled water and 60 parts of liquid ammonia of sp. grav. 0·87 or 0·88; to this is added drop by drop after filtration 7½ parts of tartaric acid first dissolved in 30 parts of distilled water. This liquid (solution No. 1) is retained on the surface of the glass by simple capillarity. It is left about 15 minutes, care being taken that every part which is to be silvered shall be well moistened with it, and at the end of this time the glass is inclined and the liquid allowed to run off, mixed with a considerable quantity of non-adherent silver, into grooves arranged around the table; it is then washed, and after being replaced in its former position, the second coating of silvering is applied (solution No. 2), which differs from the first only in containing a double quantity of tartaric acid. This must remain on for 25 minutes, after which, the glass after being washed with distilled water is laid in a very oblique position, and then covered with a coating of red lead and oil, which dries rapidly.

The first coating itself produces a coating which reflects perfectly, but which, although adhering strongly, would not be solid enough to receive the coating of paint; if the glass in this condition be held up to the light, many defects in the coating will be seen, which disappear after the second coating.

According to the experiments of the committee, the first coating represents about 12 grammes of silver to the square metre (17·2 grs. per sq. foot), and the two coatings together 29 grammes (41·57 grains per sq. foot). There would perhaps be an advantage in prolonging the contact of the liquids with the glass, as experiment shows that they continue to deposit their silver for several hours after their decantation; yet the liquid always retains at least one-half of the silver in solution.

This process (the committee says) gives satisfactory results both for plane and curved mirrors; and for the ordinary mirrors found in commerce, the expense does not exceed that of the ordinary method, over which it has the advantage of not being endangered by being put in any position either while carrying or when hung. It also appears to have the advantage of not being affected by moisture or exposure to

sun-light. But they are not proof against vapors containing sulphuretted hydrogen; these, especially when aided by moisture, are not completely guarded against by red lead.—*Bulletin de la Societè d'Encouragement pour l'Industrie Nationale,* May, 1860.

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For the Journal of the Franklin Institute.

*Upon the Practical Relative Economy of using Steam with Different Measures of Expansion.* By ALBAN C. STIMERS, Chief Engineer, U. S. Navy.

The most simple and obvious mode of using steam to obtain power in a steam engine, is to permit it to flow freely from the boiler into the cylinder during the entire stroke of the piston; and this was the plan adopted in the earliest engines.

The ingenious and philosophical mind of Watt, however, upon the announcement by Mariotte that the volume of the fixed gases, when maintained at a constant temperature and unaffected by the greater or less proximity of their molecules, was inversely as their pressure, or, conversely, that the pressure was inversely as their volume, soon made the application to steam; and, assuming this law and this application of it to be correct, it is easily shown that great gains in economical effect are produced by suppressing the flow of steam into the cylinder before the piston has completed its stroke, and permitting it to expand during the remainder. This was done by Watt, and apparatus for effecting this suppression at any desired point in the stroke, forms one of his many patents; but, notwithstanding the fact that both his mechanism and his patent covered the whole ground of the expansion question, that is, enabled him to cut off at any point in the stroke, his engines, which were generally paid for by a portion of the fuel he saved over that used by those displaced, were arranged, after a few trials, for suppressing the steam at about three-fourths the stroke of the piston.

Any one familiar with Watt's history must have observed how uniformly he put every important conception tending to improve the steam engine to the test of a practical experiment; and though we have no account of an especial set of experiments having been tried by him to test the exact value of the expansion principle, there is but little doubt that his very accurate practice would soon determine whether the practical result was equal to the theoretical prediction, and that, when he found it was not, he determined by a complete set of experiments the most favorable degree of expansion and its actual value in the practical steam engine. The fact that he published no account of such experiments is no proof against their having been made, as he had every incentive as a business man to permit his rivals to follow the natural proneness of mankind for settling all such questions by mathematical demonstration rather than by carefully-conducted experiments, which require time, money, ingenuity, patience, and a much greater knowledge of the physical laws, for drawing correct inferences from the experimental data than is needed in any cal-

culation where the data is all assumed; having ascertained to his own satisfaction that all such calculations, based upon his own invention, the indicator diagram, would lead them to adopt a more unfavorable degree of expansion than had been decided upon for him by his experiments, thus causing them to produce engines inferior to his own.

The steam engine establishment of Boulton and Watt is still in existence, having descended from father to son during eighty-six years, and the general practice of the present firm with regard to this question is the same to-day that it was sixty years ago. It cannot be considered as at all strange that the practice of so successful and celebrated an establishment should be imitated as closely as possible by a large majority of steam engine builders as soon as the expiration of their patents destroyed their monopoly; and this we find to have been the case in fact, even in our own country. The swift and powerful steamers upon the Hudson, in their palmiest days, only differed materially from the practice of the above establishment by using a higher pressure, the steam being cut off almost uniformly at five-eighths of the stroke of piston. The same degree of expansion is also used in the engines of the steamers upon the Mississippi and its tributaries.

It is true that in river boats the greater dimensions and consequent weight of the larger engines required to use the steam very expansively may be a much greater objection than it is in most of the applications of steam power, and that, consequently, the fact of the lesser degree of expansion being used in them, is not in itself a proof of its greater economy; but, an examination of the subject will prove that the advantages of obtaining great power with small engines are not, in either of these instances, at the expense of economy in fuel.

Until quite recently, it was the exception, and not the rule, to find new engines cutting off at less than half the stroke of the piston, and even now it is doubtful if a majority of all the steam engines in existence are arranged for expanding the steam as much as twice. The impression, therefore, which appears to be quite general, that any experiments which prove that the law of Mariotte cannot be applied to the practical steam engine to determine its economy when the steam is being expanded several times, are contrary to the experience of the whole engineering profession ever since its birth, is a very mistaken one. The indefatigable persistence, however, of the patentees of adjustable cut-offs, who wish to "sell rights," together with the remarkable coincidence which exists between the indicator diagram as formed by an engine when expanding the steam several times, and that called for by the simple application of the law of Mariotte, have exerted of late years a powerful influence in causing engines to be built with the design of permitting the steam to expand a great number of times.

The apparent success of some of the extreme applications lately made of this principle, was rapidly causing a great revolution in the practice of the profession; so much so, that when Chief Engineer Isherwood, of the U. S. Navy, had the practical sagacity to perceive that the actual economy of any engine in which the steam was greatly expanded was not nearly equal to what it should have attained if there

had been no drawbacks to the application of the theory, and proceeded to publish a book, giving, among other things, an account of experiments he had made to test the question, and explaining their rationale, it was met with severe criticism from nearly every quarter. He was looked upon as a man who was endeavoring to thrust the steam engine back into the darkness from which it was just emerging. By no one was this view taken more strongly than by the present writer, who shared the general feeling that the experiments detailed in the book were not of a character to justify its author in what appeared to be such radical conclusions, overthrowing, at one fell stroke, all our preconceived ideas respecting the power of the indicator diagram to determine the amount of steam which had entered the cylinder.

After the issue of the above book, and during the year 1860, Mr. Isherwood was almost constantly engaged, under orders from the Navy Department, in experiments showing the relative economy of using steam with different manners of expansion. Such of the results of these as became known to the public, were so different from what would have been predicted by what had become to be regarded as established theories, that a memorial was addressed by a large number of steam engine manufacturers and others, to the Secretary of the Navy, praying him to cause a complete set of experiments to be tried with the engines of some of our national vessels by a Board of Naval Engineers. This was granted, and a Board, consisting of Chief Engineers B. F. Isherwood, Theodore Zeller, Robert H. Long, and Alban C. Stimers, was ordered to convene on board the U. S. Steamer *Michigan*, at Erie, Penna., on the 19th of November, 1860.

When the writer joined this Board, he had very little doubt about the result. He had been taught in his engineering education to consider the indicator diagram as an exponent of the economy of the engine which formed it, whatever the degree of expansion, and although he had experienced some unaccountable deficiencies in the evaporative powers of boilers attached to engines using large measures of expansion, he had never suspected that the difficulty lay in the engines and not in the boilers or the coal. And as an experiment was not in itself an argument upon this side or that of any question, but the true determination of the real facts; he believed that these would prove to be, that decided benefits were obtained by expanding the steam as many as three times at least in that kind of engines, namely: unjacketed cylinders using saturated steam, and without regard to the opinions or expectations of the others, he satisfied himself thoroughly of the propriety of every preparation made before commencing the experiments and watched narrowly their whole conduct afterward; being determined that whatever they would be to people in general, to him they should prove the *experimentum crucis*, as far as these engines were capable of determining the question. This they have done, and they prove to his entire satisfaction that it is utterly futile to attempt to realize any benefit by expanding the steam beyond one and a half times, under the conditions above described.

The following description of the machinery; of the manner of making

the experiments; of obtaining the data; and of calculating the results; together with the reasons for the same, and the reductions formed, may be considered as condensed from the Report of the Board, which being very minute and circumstantial, is too long for a magazine article.

The selection by the Navy Department of the machinery of the U.S. Steamer *Michigan* for making these experiments was determined by its appropriateness and convenience; the engines being of the medium size used for marine purposes and the vessel out of commission; the former had just been thoroughly repaired and furnished with new boilers.

*Description of the Boilers.*—The boilers are two in number, placed side by side, six inches apart, with one smoke-pipe in common at the front end. They are of the type known as *Martin's patent*, but with proportions somewhat different from those adopted by the patentee; these were designed by Samuel Archbold, Esq., the Engineer in Chief of the Navy, for the purpose of burning to the greatest advantage the highly gaseous coal found on the borders of Lake Erie, in Pennsylvania and Ohio, and universally used by the steamers on the lakes, to the waters of which the cruising of the *Michigan* is confined.

These peculiarities are:

1. The greater length of the tube-box, which is about one and a half times more than the patentee employs.

2. The greater width in the clear between the tubes crosswise the furnaces, which is about two and a half times that which the patentee employs.

3. The greater calorimeter for draft between the tubes, which is double the patentee's proportion, while the area of the smoke-pipe, instead of being equal to this calorimeter, is only about half of it.

4. The employment of a much larger combustion chamber between the furnace and the tubes than the patentee adopts.

5. The furnishing a copious supply of air, not only to the furnaces through perforations in the doors, but to the bottom of the combustion chambers, through perforations in the lower part of the bridge-wall.

The whole of the boilers and steam chimney are well covered with felt. The heating surface given below is calculated for every part with which the heated gases come in contact—top, sides, and bottom—and for the external circumference of the tubes.

The following are their principal dimensions:—

| | | | | | | |
|---|---|---|---|---|---|---|
| Length of each boiler at the furnaces (fore and aft the vessel), | | 15 | feet | 8 | inches. |
| " " at top of flues, | | 16 | " | 8 | " |
| Breadth " | | 9 | " | 2 | " |
| Height " exclusive of steam chimney, | | 9 | " | 2 | " |
| Number of furnaces in each boiler, | 3. | | | | |
| Width of each furnace, | | 2 | " | 6 | " |
| Length of grate bars, | | 6 | " | | |
| Height from bottom of ash-pit to top of grate bars at front of furnace, | | 1 | " | 9 | " |
| Height of crown of furnace from bottom of ash-pit at front of furnace, | | 4 | " | | |
| " " from top of bridge-wall, | | 1 | " | 3 | " |
| External diameter of tubes, | | | | 2 | " |
| Length of tubes between tube sheets, | | 1 | " | 8 | " |
| Whole number of tubes, | 1504. | | | | |
| Total area of grate surface, in both boilers, | 90 sq. ft. | | | | |
| " of water-heating surface, in both boilers, | 2689·59 " | | | | |
| " of steam-heating " " | 84·71 " | | | | |

Diameter of the smoke-pipe, . . . 4 feet 3 inches.
Height " above grate surface, . 45 "
Steam space in the two boilers and steam chimney, 530 cub. ft.
Weight of water in the two boilers, at a temperature of 262° Fahr., measured to the height carried during the experiments, 46,450 lbs.

| | | |
|---|---|---|
| PROPORTIONS.—Ratio of | water heating to grate surface, . | 29 884 to 1. |
| " | steam " " . | 0·941 to 1. |
| " | grate surface to least cross area betw'n tubes, | 3·212 to 1. |
| " | " to area of smoke-pipe, . | 6·344 to 1. |

*Description of the Engines.*—The engines are two in number, condensing, direct-acting, and inclined from the keel at an angle of 23 degrees: they are placed side by side in the vessel with a passage-way $4\frac{1}{4}$ feet wide between them. They occupy in the vessel a space 15 feet wide, including the above passage between them, by 35 feet long, and a height from top of keelsons to top of main pillow blocks of $13\frac{1}{2}$ ft.

The air-pump is inclined like the cylinder, the axis of both being parallel. It is a single-acting piston-pump, with a solid piston, and one end open to the atmosphere.

The condenser is the common jet kind, situated immediately beneath the cylinder.

The cylinder steam and exhaust valves are the double poppet kind habitually used in the United States for marine paddle-wheel engines. The upper and lower valve chests are connected by a steam and an exhaust pipe, the axes of which are parallel with the axis of the cylinder.

The cylinder steam valves are made to act as expansion valves by means of a valve-gear known as *Sickle's cut-off.* As applied to these engines, the valve was tripped by its own movement when the spring came in contact with the inclined face of a fixed cam, which could be adjusted by means of a screw. By this arrangement, the point of cutting-off could be graduated from nearly the commencement up to $\frac{4}{9}$ of the stroke of the piston, and from $\frac{7}{10}$ up to $\frac{11}{12}$ of the stroke, at which point the valve seated by the eccentric movement without tripping. Between $\frac{4}{9}$ and $\frac{7}{10}$ of the stroke it was impossible to suppress the admission of the steam.

Each end of the cylinder is provided with a relief valve for the discharge of the waste water.

The steam pipe between the boilers and cross pipe to the two engines, in which is placed a throttle valve to each engine, is $25\frac{1}{4}$ feet long by $17\frac{3}{4}$ inches diameter. The cross pipe is $4\frac{3}{4}$ feet long by $15\frac{1}{4}$ inches diameter, and the steam side pipe of each cylinder is $7\frac{1}{2}$ feet long by $12\frac{1}{4}$ inches diameter, giving a total interior surface when one engine is used, for the radiation of the heat, of 156·5 square feet, and as there is a slight inclination towards the cylinder throughout the whole length of the steam pipes, any water condensed in them is passed through the cylinder.

The steam pipes, side pipes, and cylinders are protected with a thick coat of felt covered with wooden lagging. The heads of the cylinders, the valve chests, and cylinder nozzles have no covering.

The lower head of each cylinder is double, the upper one is single.

| | | | |
|---|---|---|---|
| Diameter of cylinder, | | | 36 inches. |
| Stroke of piston, | | 8 feet. | |
| Diameter of piston rod, | | | 3¾ " |
| Mean area of piston, exclusive of rod, | 1012·278 sq. ins. | | |
| Space displacement of piston per stroke, excl. of rod, | 56·514 cub ft. | | |
| Steam space comprised in the clearance and nozzle, | 3·280 " | | |
| Net area of opening through steam valve, exclusive of stem, &c., | 114·96 sq. ins. | | |
| Net area of opening through exhaust valve, exclusive of stem, &c., | 108·38 " | | |
| Diameter of air-pump, | | | 29 " |
| Stroke of air-pump piston, | | | 31⅜ " |
| Space displacement of air-pump piston per stroke, | 12 cub. ft. | | |
| Diameter of feed pump and of bilge pump, | | | 5 7-16 " |
| Stroke of piston of " " | | | 31⅜ " |
| Capacity of one condenser, | 20 " | | |
| " hot-well, | 27 " | | |
| Length of connecting rod, | | 16 " | 5 " |

Paddle Wheels.—The arms, rims, and braces of the paddle-wheels, are of iron; the paddles are of wood, 1½ inches thick, chamfered at the edges. Each paddle is divided in its breadth.

| | | | |
|---|---|---|---|
| Diameter to outside of paddles, | | 21 feet | 6 inches. |
| Number of paddles in each wheel, | 16. | | |
| Breadth of outer fraction of paddle, | | 1 " | 2 " |
| " inner " | | 1 " | 5 " |
| Length of paddles, | | 8 " | |
| Immersion of the lower edge of paddle, | | 2 " | 8 " |

Note.—The above is the normal surface and dip, but during the experiments these greatly varied, different numbers of buckets being removed for different experiments, and sometimes several getting broken by the ice during the same experiment. The vessel, too, was so near the ground, that, as the water ebbed and flowed by the influence of the winds, it was sometimes afloat and sometimes aground, varying the dip according to the extent of the fall of the water: the experiments being made with the vessel lashed to the wharf in the harbor of Erie.

*Manner of Making the Experiments.*—The experiments were made with the starboard engine alone and with both boilers. The following are the quantities and the mode of obtaining them, which were ascertained by direct measurement or weights.

The number of double strokes made by the engine piston were registered by one of Rogers' engine counters.

The number of pounds of coal consumed, of ashes, clinker, and soot, forming the refuse from the coal, were accurately weighed on one of Fairbanks' platform scales, quite new, and tested previous to its being used.

The steam pressure in the boilers was shown by one of Allen's spring gauges and by a mercurial syphon gauge, the two coinciding.

The vacuum in the condenser was denoted by one of Allen's spring vacuum gauges.

The steam pressure in the cylinder throughout the stroke of the piston, was obtained by taking indicator diagrams hourly from each end of the cylinder with excellent instruments of the New York Novelty Iron Works manufacture. Those shown in the plate are fair samples of those taken during each experiment.

The pressure of the atmosphere was denoted by an aneroid barometer, which hung in the centre of the engine room. This was used to determine in each case the back pressure in the cylinder.

The temperatures of the injection water, of the feed water in the tank, of the external atmosphere, and of the engine room, were measured by thermometers of the ordinary description; that of the hot-well was shown by a large fixed thermometer having its bulb constantly immersed in the water in the interior of the well.

The feed water, before being pumped into the boilers, was first pumped into a wooden tank lined throughout with zinc, and as the hose through which the water was each time pumped into it and the pipe through which it was withdrawn by the feed pump passed over the top, there were no joints to cause leakage. In addition to this precaution against error in measuring the amount of water evaporated, the tank was blocked up from the engine room floor 3 inches; so that if any leakage should occur from any cause, it would be immediately discovered. The internal dimensions of the tank were as follows:—length $11\frac{1}{4}$ feet, breadth $1\frac{3}{4}$ feet, height $3\frac{7}{8}$ feet. It was filled each time to a convenient mark which corresponded accurately with a capacity of 70 cubic feet. Great care was taken in making the connexions between this tank and the feed pump to shut off absolutely every other source from which the pump could be supplied, and to close all avenues of egress from the pump except those which conducted the water to the boilers.

The boilers were fitted with the usual gauge cocks and with glass water gauges; these latter enabled the height of the water within to be noted with great exactness by tying a piece of small twine around the glass tube at the height of the water. When an experiment was commenced, the piece of twine was made to correspond exactly with the water level, which was brought again to the same level at the end of the experiment.

The water supplied to the boilers being fresh and almost absolutely pure, no blowing off was required; all the water, therefore, which was measured in the tank was available for making steam. Great care was taken before commencing the experiments to have all valves and cocks through which water or steam could leak from the boilers made absolutely tight, and afterwards a regular system of inspection was adopted that any new leak might be at once discovered. With regard to the boilers themselves, they were quite new, and, as far as could be ascertained by the most rigid scrutiny, were absolutely tight.

Each experiment lasted 72 consecutive hours, during which the engine was neither stopped, slowed down, nor in any way changed in condition. In commencing an experiment, the engine was operated for several hours to adjust it to the normal conditions required to be uniformly maintained during that experiment and to bring the fires to steady action. When all was ready, average fires and the proper steam pressure being in the boilers, the time and number of the engine counter were noted, and the experiment began. From this time up to the end of the 72 hours all the quantities were weighed or measured and

noted hourly in a regular *log*, ruled with appropriate columns. As the end of the experiment approached, care was taken to bring the fires to the same state of cleanliness and to the same thickness which they had at the beginning. The means or totals then, as the case required, of the quantities entered in the log furnished, with the exception of the facts derived from the indicator diagrams, the data for that experiment.

Each of the 144 diagrams taken during one experiment was carefully analyzed and its results arranged in tabular form, so that the mean of the whole number was conveniently obtained by getting the mean of the whole number of quantities in each column of the table. The quantities thus found were,

The pressure in the cylinder at the commencement of the stroke,
The pressure in the cylinder at the point of cutting off,
The final pressure at the end of the stroke of the piston,
The mean back pressure,
The mean gross effective pressure, and
The fraction of the stroke completed when the steam was cut off.

At the close of the experiments, the pressure on the piston required to operate the engine *per se* was obtained by removing all the paddles from the wheels and running the engines, taking indicator diagrams to get the pressure. Of course the arms of the paddle wheels acted, to a certain extent, propulsively upon the water, and to eliminate this quantity the engine was run at various speeds, ranging from 8 to 22 double strokes per minute, and taking several sets of diagrams for each rate of speed to get a reliable mean. Now, the resistance to the passage of the paddle wheel arms through the water was variable and required an increased piston pressure with each increase in the speed, while the piston pressure required to overcome the friction of the engine would be constant for all speeds; by eliminating, then, the variable quantity, the constant quantity remaining would be the correct pressure required solely for overcoming the friction. This was found to be 2·1 pounds per square inch.

In reporting the experiments, the Board make out two tables containing all the data and results observed and calculated; embracing only those trials in which all the conditions from beginning to end were such as could satisfy the most hypercritical, and moreover they are those which give the highest results to the greater measures of expansion. The first table contains the exact experimental determinations under the conditions noted, and is made out in great detail. The second contains the results detailed in the first, but calculated only for weight of steam used in rapport of power developed, and corrected for equality of back pressure against the piston, which equality did not obtain in the experiments, but which it is necessary to adopt in order to show the *true* relative economy of the different measures of expansion employed; for whatever absence of back pressure can be obtained in one case can in any other. This second table of the Report contains, therefore, all that is really essential to a correct understanding of the results obtained by the experiments, and is the only one of the two given in this paper.

TABLE: *Containing the Results of the Experiments, calculated for Equality of Back-pressure against the Piston, and showing the True Relative Economy of using Steam with Different Measures of Expansion.*

| | | | Fraction of Stroke Completed when Steam was Cut Off. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | $\frac{11}{12}$ | $\frac{7}{10}$ | $\frac{4}{9}$ | $\frac{3}{10}$ | $\frac{1}{4}$ | $\frac{1}{6}$ | $\frac{4}{45}$ |
| 1 | Steam Pressure in Cylinder per Indicator. | In pounds per square inch above zero at beginning of stroke of piston, | 34·8 | 33·3 | 34·5 | 34·4 | 34·3 | 34·2 | 34·7 |
| 2 | | " " " at point of cutting off the steam, | 32·2 | 31·4 | 33·0 | 33·4 | 33·3 | 33·2 | 33·0 |
| 3 | | " " " at end of stroke of piston, | 29·3 | 22·2 | 15·7 | 11·0 | 9·7 | 7·8 | 5·9 |
| 4 | | " " " against piston during the stroke, | 2·7 | 2·7 | 2·7 | 2·7 | 2·7 | 2·7 | 2·7 |
| 5 | | Mean gross effective pressure in pounds per square inch on piston during its stroke, | 31·3 | 28·4 | 24·1 | 20·2 | 17·4 | 13·7 | 9·8 |
| 6 | | Pressure in pounds per square inch on piston required to work the engine, *per se*, | 2·1 | 2·1 | 2·1 | 2·1 | 2·1 | 2·1 | 2·1 |
| 7 | | Mean net effective pressure in pounds per square inch of piston, | 29·2 | 26·3 | 22·3 | 18·1 | 15·3 | 11·6 | 7·7 |
| 8 | | Per centum which the mean net effective pressure is of the total pressure, | 85·9 | 84·6 | 82·3 | 79·0 | 76·1 | 70·7 | 61·6 |
| 9 | Power Absolute. | Gross effective horses power developed by the engine, | 316·601 | 216·905 | 206·966 | 135·727 | 118·434 | 75·095 | 67·821 |
| 10 | | Total horses power developed by the engine, | 313·915 | 237·527 | 229·868 | 153·869 | 136·812 | 89·895 | 86·506 |
| 11 | | Net horses power usefully applied, | 295·362 | 200·867 | 189·153 | 121·617 | 104·140 | 63·584 | 53·288 |
| 12 | Power Economic. | Pounds of steam consumed per hour per gross effective horses power, | 38·029 | 33·817 | 32·671 | 34·681 | 34·472 | 36·769 | 41·382 |
| 13 | | " " " total " | 35·008 | 30·881 | 29·416 | 30·592 | 29·841 | 30·715 | 32·044 |
| 14 | | " " " net " | 40·763 | 36·561 | 35·748 | 38·705 | 39·202 | 43·425 | 52·669 |
| 15 | | Speed of the piston in feet per minute, | 329·741 | 248·967 | 276·512 | 219·010 | 221·888 | 178·688 | 225·600 |
| 16 | Comparative. | Comparative bulks of steam withdrawn from the boilers in equal times, | 1·000 | 0·609 | 0·561 | 0·391 | 0·339 | 0·229 | 0·233 |
| 17 | | Mean total pressure on piston in pounds per square inch, by Mariotte's law, | 34·5 | 31·3 | 27·6 | 23·2 | 21·2 | 17·2 | 12·6 |
| 18 | | " " " by experiment, | 31·0 | 31·1 | 27·1 | 22·9 | 20·1 | 16·4 | 12·5 |
| 19 | | Comparative economic result, by Mariotte's law, for the total horses power, | 1·000 | 0·835 | 0·660 | 0·568 | 0·532 | 0·475 | 0·422 |
| 20 | | " by experiment, for the gross effective horses power, | 1·000 | 0·889 | 0·855 | 0·912 | 0·906 | 0·967 | 1·088 |
| 21 | | " " total " | 1·000 | 0·882 | 0·840 | 0·874 | 0·852 | 0·877 | 0·915 |
| 22 | | " " net " | 1·000 | 0·896 | 0·877 | 0·949 | 0·962 | 1·065 | 1·292 |
| 23 | | Comparative capacity of cylinder required to develop equal net horses power, | 1·000 | 1·110 | 1·309 | 1·613 | 1·909 | 2·517 | 3·792 |
| 24 | Condensation. | Weight of steam condensed in the cylinder due to the heat annihilated in producing the total power, according to Joule's equivalent; expressed in per centum of the feed-water, | 7·80 | 8·74 | 9·04 | 8·59 | 8·77 | 8·45 | 7·94 |
| 25 | | Discrepancy between the tank and indicator measurements of the feed-water; expressed in per centum of the latter, | 2·91 | 6·60 | 18·14 | 33·07 | 30·84 | 33·66 | 37·16 |

## Explanation of the Table.

For facility of reference, the quantities are arranged in groups, and the lines containing them numbered.

Line 4 contains the corrected back-pressure above zero, in pounds per square inch against the piston during its stroke. The quantity 2·7 pounds was adopted for this purpose, because it is the least given during the experiments, and as with equal initial cylinder pressures the results are more unfavorably affected by back-pressure as the steam is used more expansively, it was deemed proper to accept the least practicable. The average with steam engines under the conditions of ordinary practice, is about 4 pounds, which, if adopted, would make the economic results much less favorable to the greater measures of expansion.

Lines 5 and 7 have been corrected from the experimental determinations to what they would have been, had the back-pressure been uniformly 2·7 pounds.

Lines 9, 10, and 11, contain, respectively, the gross effective, the total, and the net indicated horses power developed by the engine when using the pressures given on lines 5, 18, and 7, and having a speed of piston corresponding to those given on line 15.

Lines 12, 13, and 14, contain, respectively, the number of pounds of feed-water consumed per hour to produce the gross effective, total, and net indicated horses power, as given before.

Line 17 contains the mean total pressure, or pressure above zero on the piston, in pounds per square inch, that should exist according to the law of Mariotte. It is calculated for the experimental conditions of the steam comprised in the clearance and cylinder nozzles, and of the cylinder pressures at the beginning of the stroke, and at the point of cutting off the steam (lines 1 and 2). By comparing the quantities on this line with those on line 18, which are the mean total pressures on the piston as shown by the indicator, a remarkable coincidence will be found. That it is only a coincidence, is evident when it is remembered that, in order that the one should be a consequence of the other, it would be necessary that neither condensation, from any cause, nor re-evaporation should have occurred in the cylinder, from the point of cutting off to the end of the stroke of the piston, and that the steam should have expanded precisely in the inverse ratio of the spaces occupied.

Line 19, exhibits, comparatively, the economic result that should have been obtained with the different measures of expansion used for the steam, according to Mariotte's law. The calculation is made for the total horses power developed, and for the conditions which were obtained in the experiments, with the exception, only, that the steam is supposed to follow this law, agreeably to the general belief among engineers. In order to ascertain how nearly the steam comes up to the assumed law, in the ordinary steam engine cylinder, it is only necessary to compare the quantities in this line with those on line 21, which show the comparative cost of obtaining a given total horse

power, with the different measures of expansion employed, as determined by the experiments.

It is plain from these figures that the law of Mariotte cannot be employed to determine, even approximately, the economy of any engine which is using the steam expansively to any extent; although, in calculations for simply determining the power, it appears to be as safe a reliance as has all along been supposed by the most firm believer in its applicability to steam when expanding in an engine cylinder. Indeed, engineers were in the habit of making this comparison, which is readily done from the indicator diagram itself when the clearance is known, and it was one of the evidences which satisfied the mind that there was no danger of making any material error in taking the diagram as an exponent of the economy of the engine. Any difficulty in getting the expected economy from large measures of expansion, always appeared to be that the boilers failed to evaporate the proper amount of water per pound of coal, and either they or the coal itself were condemned as not being equal to expectation: the guilty engine not being even suspected.

Line 22 gives, comparatively, the cost in fuel of a given useful effect produced by the engine, and determines, *per se*, the practical relative economy with regard to fuel alone, of using steam with the different measures of expansion employed. To determine, however, the propriety of designing an engine with the view of using the most economical measure of expansion employed in the experiments, it is necessary to consider, in connexion with this, the quantities on line 23, which show the comparative capacity of cylinder required to produce, *cæteris parabus*, a given power with the net effective pressures given on line 7. The weight, space occupied, and first cost of steam engines proper, decrease in a more rapid ratio than the capacities of their cylinders. It is, therefore, perfectly safe to assume that these quantities vary with those on line 23, and, when this is done, an estimate, however roughly approximative, points inevitably to the fraction of $\frac{7}{10}$ as being the most economical one for cutting off the steam.

Lines 24 and 25 exhibit the difference, due to all causes, between the weight of feed-water pumped into the boilers, according to the tank, and the weight of steam discharged from the cylinder into the condenser at the end of the stroke of the piston, per indicator, expressed in per centums of the feed-water. Line 24 shows that part of it which is condensed in consequence of the heat annihilated in the cylinder to produce the total power developed by the engine, according to Joule's equivalent of one pound of water raised one degree of temperature on Fahrenheit's scale for every 772 foot-pounds developed by the engine; which would make the thermal equivalent of one indicated horse power, $\left(\frac{33,000}{772} = \right)$ 42·7461 pounds of water raised one degree Fahrenheit.

To make the calculation, let $k =$ the number of *total* indicated horses power (line 10), developed by the engine; $e =$ the total heat

of steam of the pressure at the end of the stroke of the piston (line 3), in degrees Fahr. according to Regnault; $g =$ the temperature in degrees Fahr. of the same steam; and $t =$ the time in minutes ($60 \times 72 = 4320$) during which the power, $k$, acted: then, $\frac{k \times 42{\cdot}7461 \times t}{e - g}$ $=$ the number of pounds of steam condensed from this cause during one experiment. The per centum which this total quantity is of the total quantity pumped into the boilers during the experiment, is then obtained for the quantities on line 24.

The causes of the remaining differences, given on line 25, may be numerous. If the boilers lose water by leakage, by priming, or by passing it over to the cylinder in the vesicular state, the quantity thus lost will be included. If the cylinder valves or the piston leak steam to the condenser, the quantity thus leaked will be included. If the steam be condensed in the steam-pipe, valve-chests, or cylinder, from any causes other than the production of the power, and if a portion of the water formed by this condensation be re-evaporated in the cylinder, then the difference of the weights condensed and re-evaporated will be included. By taking these quantities into consideration when comparing the economic results for total powers that should have been obtained according to the law of Mariotte (line 19) with those obtained by experiment (line 21), a very clear idea will be had of the great antagonistic cause that neutralizes and reverses the economy promised by the purely abstract conditions on which that law is founded.

## Discussion of the Results.

*The Initial Pressure.*—In examining the preceding table, it will be observed that particular care was taken to maintain the initial cylinder pressure (line 1) the same in all the experiments as nearly as practicable. That this is a proper condition for the purpose of the experiments, will be obvious when it is considered that degree of pressure is purely a question of boiler, and not at all one of engine. It is just as feasible to carry a high pressure and cut off the steam at $\frac{7}{10}$ of the stroke of the piston, as it is when cutting off at $\frac{1}{10}$, if the cylinder of the engine be of the proper dimensions. In considering subjects of this nature, it is very important that they be properly analyzed, so that but one element is determined at a time. To give the larger measures of expansion the benefit which is due to a higher pressure of steam, is not the way to ascertain how much benefit there is to be derived from expansion *per se*,—the object of these experiments.

It is, however, very useful to know the relative economy of developing, in the same engine, the same power with different measures of expansion; the greater measures having a correspondingly higher initial pressure in the cylinder, so that equal mean net pressures are exerted upon the piston during its stroke. The principal gain in using a higher pressure of steam in the cylinder of a steam engine, is to reduce the per centum of loss by the sum of the back and friction pressures, but when comparing results from *total* pressures alone, this element could not of course enter into consideration. Now, if we have

with the different measures of expansion, different initial pressures, such as the *net* pressures are equal, we shall have also equal *total* pressures; as the back and friction pressures are constant quantities; and as, leaving out of consideration the slight increase of dynamic effect due to increased temperature in the higher pressures, any numbers which express the comparative economy of different measures of expansion in rapport of *total* power are independent of the initial pressure of the steam; they express also the comparative economy of the same measures of expansion in rapport of *net* power, when equal mean pressures are maintained during the different degrees of expansion. The numbers, therefore, in line 21 express the comparative economy of the different measures of expansion employed in the experiments when the same engine is used to exert the same power, but with increased initial pressure with each increase in the degree of expansion.

*Modification of Power.*—The economic efficiency of any given engine is greatest when using its maximum mean total pressure; because then it has both the advantages of the greater dilatation due to the higher temperatures and the greater proportion of *net* to *total* pressure. In most applications of the steam engine, however, it is necessary to sometimes use considerably less than the maximum power, and it becomes a question of considerable importance to know how to do it with the least loss of economical efficiency. There are three modes in common use for reducing the power of the engine below the maximum, as follows: 1st, By reducing the boiler pressure; 2d, By partially closing the throttle valve and maintaining the same boiler pressure; and, 3d, By suppressing the steam at an earlier portion of the stroke by means of an adjustable cut-off and maintaining the same boiler pressure.

The impression obtains very generally among engineers, that the second of these plans is a decided improvement upon the first, and that the third is a still more decided improvement upon the second.

The first method reduces the mean pressure without any change whatever in the degree of expansion. The third does it entirely by in creasing the measure of expansion, and the second may be said to be a compromise between the other two methods. Now, it happens, fortunately, that the foregoing table furnishes all the necessary experimental quantities required for determining the relative economy of the first and third methods, and as the second falls between these two, it will hereafter be seen that it is not important to know its exact economy.

The first three and the fifth lines in the following table are taken from the foregoing general table. Line 1 represents the total pressures, line 2 the net pressures, and line 3 the per centum which the latter are of the former. These last quantities represent the relative net power that would be obtained per unit of weight of fuel when using the steam with the same measure of expansion, but with the different net pressures on line 2; and by dividing unity by each of them we obtain a new set of quantities that show the relative cost in fuel of the unit of net power. Then, calling the one unity which falls into the column headed $\frac{7}{10}$ (that being the point recommended for permanently cutting off the steam), we obtain the proportional quantities on line 4,

which represent the comparative cost of the power when maintaining the same degree of expansion, and changing the net pressures to those found in the other columns on line 2 by varying the boiler pressure.

The quantities on line 5 are those on line 22 of the general table, but arranged for unity in the column headed $\frac{7}{10}$, instead of that headed $\frac{11}{12}$, and show the comparative economy of changing the net pressures to those found in the other columns on line 2 by retaining the same initial pressure and varying the measure of expansion.

The differences between the respective quantities on these two lines are given on line 6, and represent the per centum of loss or gain experienced by avoiding a complicated piece of mechanism, and reducing the power by merely reducing the boiler pressure without the assistance of any mechanism whatever.

| | Fraction of the Stroke Completed when the Steam was Cut Off. | | | | | | |
|---|---|---|---|---|---|---|---|
| | $\frac{11}{12}$ | $\frac{7}{10}$ | $\frac{4}{9}$ | $\frac{3}{10}$ | $\frac{1}{4}$ | $\frac{1}{6}$ | $\frac{4}{45}$ |
| 1 | 34·0 | 31·1 | 27·1 | 22·9 | 20·1 | 16·4 | 12·5 |
| 2 | 29·2 | 26·3 | 22·3 | 18·1 | 15·3 | 11·6 | 7·7 |
| 3 | 85·9 | 84·6 | 82·3 | 79 0 | 76·1 | 70·7 | 61·6 |
| 4 | 0·985 | 1·000 | 1·027 | 1·061 | 1·111 | 1·196 | 1·373 |
| 5 | 1·116 | 1·000 | 0·978 | 1·059 | 1·073 | 1·188 | 1·442 |
| 6 | Gain, 13·1. | | Loss, 4·9. | Loss, 0·2. | Loss, 3·8. | Loss, 0·8. | Gain, 6·9. |

It will readily be perceived that for greater measures of expansion than that obtained by cutting off at $\frac{7}{10}$, there is really no practical difference in the economy of the two methods; and as the use of the throttle valve, the most convenient of the three plans, comes between the other two in its economic efficiency, it may be considered as neither more nor less economical than the adjustable cut-off, but has the decided advantage of being extremely simple in its construction and convenient to manage.

*Loss by clearance in the Cylinder.*—There is a loss of useful effect in every steam engine by being required to fill the *clearance* at every stroke; and the per centum of this loss is different with different measures of expansion. An examination of the subject will tend to explain in part why we do not obtain in practice the whole benefit promised by the theory of expansion.

When the engine is working full stroke, the per centum of loss is exactly equal to that which the amount of space comprised in the clearance, is of the whole space filled with steam per stroke. In the case of using steam expansively, however, this ratio is modified; a part of the steam in the clearance producing a dynamic effect during expansion, and on the other hand, the space comprised in the clearance being constant, the shorter the steam is cut off the greater becomes the ratio which this space bears to that filled with steam before the valve closes.

To ascertain the per centum of loss experienced from this cause, it is necessary to imagine an engine running without any clearance what-

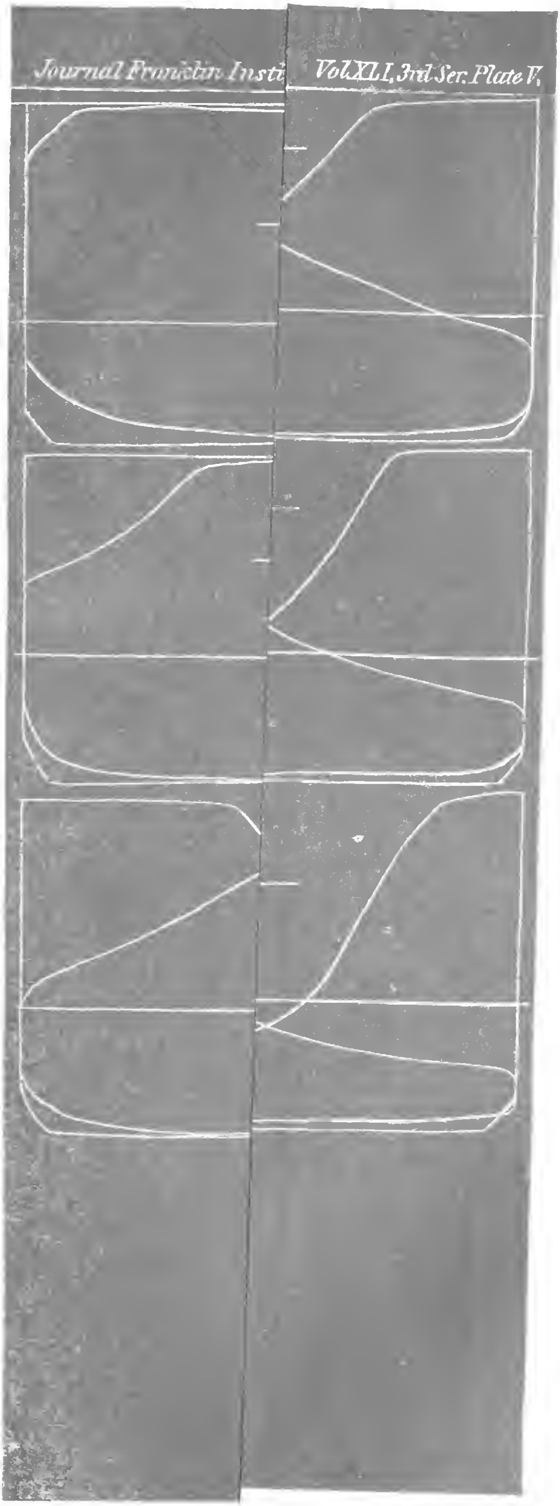
ever, and to compare its economy with that experimented upon. The results of such a comparison are given in the following table. Line 1 contains the effective pressures in pounds per square inch on the piston according to the law of Mariotte under the experimental conditions. Line 2 contains what would have been the net effective pressures according to the same law had there been no clearance and had the same amount of steam been admitted to the cylinder per stroke; in which case the measures of expansion would have been correspondingly lessened. Line 3 contains the difference between the quantities on lines 1 and 2. Line 4 contains the per centums which the quantities on line 3 are of those on line 2.

| | Fraction of the Stroke Completed when the Steam was Cut Off. | | | | | | |
|---|---|---|---|---|---|---|---|
| | $\frac{11}{12}$ | $\frac{7}{10}$ | $\frac{4}{9}$ | $\frac{3}{10}$ | $\frac{1}{4}$ | $\frac{1}{6}$ | $\frac{4}{45}$ |
| 1 | 29·7 | 26·5 | 22·8 | 18·3 | 16·4 | 12·4 | 7·8 |
| 2 | 29·9 | 26 9 | 23·9 | 19·8 | 17·8 | 14·1 | 9·1 |
| 3 | 0·2 | 0·4 | 1·1 | 1·5 | 1·4 | 1·7 | 1·3 |
| 4 | 0·07 | 1·49 | 4·60 | 7·58 | 7·86 | 12·06 | 14·29 |

An inspection of line 4 of the above table will show how rapidly the loss due to clearance increases with the measure of expansion.

*Condensation in the Cylinder.*—A comparison of the quantities on line 25 of the general table, will give at once a correct impression of the principal cause why we do not obtain in practice any approach to the gain promised by the theory when using steam expansively. The discrepancy between the indicator and tank measurements of the water evaporated it will be observed, is very small, only 2·91 per centum, when cutting off at $\frac{11}{12}$, but rapidly increases to the enormous amount of 33·07 per centum, when cutting off at $\frac{3}{10}$, and this is considered as using expansion very moderately. In the 2·91 per centum is included every kind of leakage, and the condensation due to radiation of heat from the steam-pipe, steam-chests, and cylinder, and as the loss from these causes was necessarily constant during all the experiments, it was evidently too small to be considered. Condensation within the cylinder due to the varying temperatures and pressures occurring therein at every stroke of the piston, is the only explanation which can be given; and the only accepted law of physics which could cause the condensation, requires that the surfaces with which the inflowing steam comes in contact, should be cooler than itself; the condensation taking place upon those surfaces.

The surfaces of the cylinder are cooled down below the temperature of the steam of initial pressure, partly by being in contact during a portion of each double stroke of the piston with vapor of less temperature than that to which they have been raised by the steam of initial pressure, but if we consider the slowness with which steam already formed receives additional heat, and the small amount required to elevate the temperature of that in immediate contact with the surfaces to equilibrium, it will become evident to us that this cause is hardly worth considering.

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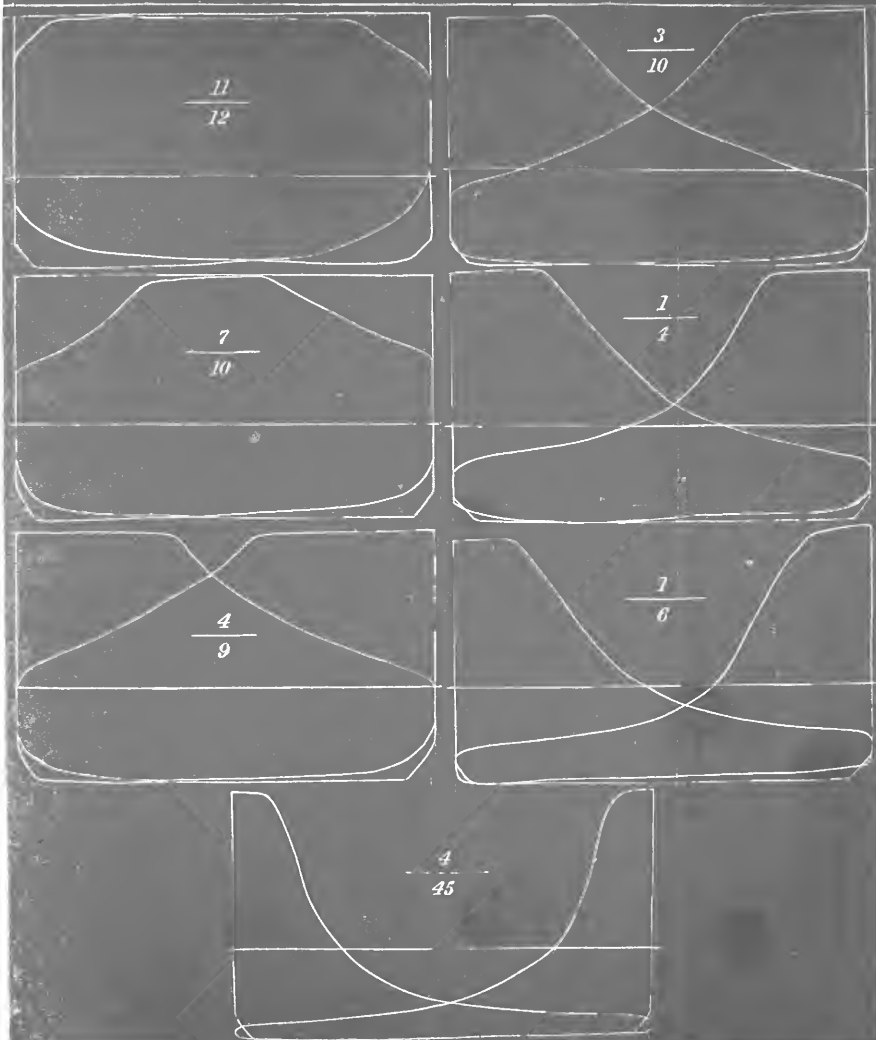
# INDICATOR DIAGRAMS.

Scale; 1 inch = 22½ lbs.



There is, however, a powerful cooling influence, entirely independent of the varying *temperatures*, and dependent only upon the varying *pressures*. It is that of evaporation from the surfaces. Let us suppose that the engine is running full stroke, and that when the steam enters the cylinder at the commencement of the stroke, the surfaces with which it comes in contact are slightly cooler than itself; condensation of a portion of the steam upon those surfaces is the only manner in which the metal can be heated to an equilibrium by the steam. They become therefore immediately covered with a dew-like film of water. This water retains the same *temperature* as that of the steam with which it is in contact, and which it would itself have shown before its condensation, the *latent heat* only of the vapor condensed, entering the metal of the cylinder. Further, when the piston commences to move, it exposes to contact with the steam, the concave surface of the cylinder which had just previously been exposed to the lower pressure and temperature on the other side, and condensation takes place upon this surface as it is uncovered by the piston throughout the stroke, so that when the piston has arrived at the end of the stroke and the cylinder is full of steam of initial pressure and temperature, its whole interior surface is covered with a thin film of water at exactly the boiling point due to that pressure. When the exhaust valve opens and the pressure falls to that of the back pressure, the temperature necessary for water to boil, falls with it. In the case of the experiments, the temperature of the water condensed under the pressure of the entering steam, was 120° Fahr. higher than the boiling point of water under the back pressure. This water, therefore, immediately evaporates, converting into the latent heat of the vapor formed, not only the surplus temperature contained within itself, but also that which had been imparted to the metal of the cylinder at the time of its condensation. In this case all the heat thus robbed from the cylinder, and which must be returned to it by a new condensation at the next stroke, goes off to the condenser and is a total loss.

In the case, however, of using steam expansively, this is modified; for, as soon as the cut-off valve has closed, the pressure commences to fall, and, although condensation upon the surfaces continually exposed by the piston still goes on, as in the case of maintaining the initial pressure to the end of the stroke, the water which had been condensed under the higher pressure commences to evaporate as soon as this pressure commences to fall; and this re-evaporation goes on throughout the remainder of the stroke of the piston, so that the whole interior of the cylinder upon the steam side of the piston is being cooled down by evaporation from its surfaces, from the moment the cut-off valve is closed until the steam is again admitted to that side of the piston. The steam resulting from this re-evaporation before the end of the stroke is measured, of course, by the indicator, and is not accounted for by the quantities on line 25 of the table; and as during that portion of the stroke which was made by the piston while each particle existed in the form of water, such particle did not exert any dynamic force; the loss in dynamic effect due to condensation within the cylin-

der is greater than is measured by its amount as given in the table; but not so great as is due to the total quantity therein condensed, which quantity was not determined by these experiments.

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For the Journal of the Franklin Institute.

## *Particulars of the Steamer Wm. G. Hewes.*

Hull built by Harlan, Hollingsworth & Co., Wilmington, Del. Machinery by Morgan Iron Works, New York. Owner, Charles Morgan. Intended service, New York to Galveston.

Hull.—Length on deck, 239 ft. 4 ins. Do. at load line, 234 ft. Breadth of beam (molded), 33 feet. Depth of hold, 10 ft. Do. to spar deck, 18 ft. Length of engine room, 76 ft. Frames—molded, 4 ins., sided, 1 in.—apart at centres, 16 ins. Sketch of shape, |; depth, 4 ins. 16 strakes of plates from keel to gunwale; thickness of plates, ½ to 11-16 in. Description of cross floors, ⏋, 18 ins. deep, 9-16 and ½ in. thick. Depth of keel, 6 ins. Diameter of rivets, ¾ in.; double riveted. One independent steam, fire, and bilge pump. 3 bulkheads. 10 fore and aft keelsons, 18 ins. high T. Cabin on deck. Draft, forward and aft, 9 feet. Tonnage, 1477·45. Area of immersed section at load draft of 9 feet, 270 sq. feet. Displacement at load line, 1253 tons. Masts, two.—Rig, schooner.

Engine.—Vertical beam. Diameter of cylinder, 50 ins. Length of stroke, 11 feet. Maximum pressure of steam, 30 lbs. Cut off at half stroke. Maximum revolutions at above pressure, 18. Weight of engines, 190,000 lbs.

Boiler.—One—Return tubular, and of steel plates. Length of boiler, 21 ft. Breadth do., 17 feet. Height do., exclusive of steam chimney, 9 feet. Weight do., with water, 102,690 lbs. Number of furnaces, four. Breadth of do., 3 ft. 6 ins. Length of grate bars, 6 ft. 8 ins. Number of tubes, above, 92; flues, below, 8. Internal diameter of tubes, above, 5 ins.; flues, below, 19 ins. Length of tubes, above, 15 ft.; flues, below, 11 ft. 4 ins. Grate surface, 93·09 sq. ft. Heating surface, 2600 sq. ft. Diameter of smoke pipe, 5 ft. 8 ins. Height of do., above grates, 50 feet. Consumption of fuel per hour, 1680 lbs.

Paddle Wheels.—Diameter over boards, 30 ft. Length of blades, 7 ft. 6 ins. Depth, do., 20 ins. Number do., 26.

Date of trial, December, 1860. C. H. H.

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For the Journal of the Franklin Institute.

## *Particulars of the Pilot Boat Wm. H. Aspinwall.*

Hull built by Messrs. J. D. & J. B. Van Deusen, foot of Sixteenth Street, East River, New York. Owners, Messrs. Geo. Berger, John N. Dale, Gideon Mapes, Wm. A. Anderson, and Capt. Walter Brewer,—all New York pilots. Intended service, Harbor of New York.

Hull.—Length of keel, 74 feet. Do. on deck, 80 ft. Breadth of beam, 19 ft. 6 ins. Depth of hold, 8 ft. 9 ins. Draft, forward, 6 feet; aft, 9 ft. 6 ins. Keel, 22 ins. deep; also, a rocking keel of 12 ins. Tonnage, 100 tons.

Masts.—Length of fore-mast, 76 feet. Do. main mast, 77 feet. Do. main boom, 46 feet. Do. fore gaff, 20 feet. Do. main gaff, 21 feet.

*Remarks.*—The *Wm. H. Aspinwall* cost $8000. Her cabin is

handsomely finished in hard wood, with maple, satin-wood, rose-wood, and black walnut, and has six enclosed berths and two state-rooms. In addition to these features, there are pantries and refrigerators in the run, steward's pantry, water tank, and coal bunkers, amidships. The forward cabin is beautifully grained in oak, contains six berths, and a commodious caboose for the necessary culinary manipulations of the sailors' friend, the "Doctor." This vessel has a sheer on deck of three feet, which gives her a very graceful and buoyant appearance as she sits on the water.

The New York pilot boats are distinguished the world over for swiftness and great beauty of model. They have furnished in many instances the original models for the very swiftest of American yachts, the reputation of which is unrivalled, and spreads far and wide. Great rivalry, consequently, exists between our respective ship-builders to excel in constructing the best and swiftest of such craft, as a successful boat of this character attracts no inconsiderable degree of interest amongst not only those directly interested, but the public generally.

Upon a late run of 50 miles by the *Wm. H. Aspinwall*, her sailing qualities, obedience to the helm in steering, &c., &c., were variously noticed and considered eminently satisfactory by all on board, there being amongst the number many who were qualified to judge. We have no doubt her future performances will reflect still greater credit on her builders. E. B.

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*United States Patent Law. An Act in addition to an "Act to promote the progress of the Useful Arts." Approved March 2d*, 1861.

*Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled*, That the Commissioner of Patents may establish rules for taking affidavits and depositions required in cases pending in the Patent Office, and such affidavits and depositions may be taken before any justice of peace, or other officer authorized by law to take depositions to be used in the courts of the United States, or in the State courts of any State where such officer shall reside; and in any contested case pending in the Patent Office it shall be lawful for the clerk of any court of the United States, for any District or Territory, and he is hereby required, upon the application of any party to such contested case, or the agent or attorney of such party, to issue subpœnas for any witnesses residing or being within the said district or territory, commanding such witnesses to appear and testify before any justice of the peace, or other officer as aforesaid, residing within the said district or territory, at any time and place in the subpœna to be stated; and if any witness, after being duly served with such subpœna, shall refuse or neglect to appear, or, after appearing, shall refuse to testify, (not being privileged from giving testimony,) such refusal or neglect being proved to the satisfaction of any judge of the court whose clerk shall have issued such subpœna, said judge may thereupon proceed to enforce obedience to the process, or to punish the disobedience in like manner as any court of the United States may do in case of disobedience to process of subpœna ad testificandum is-

sued by such court; and witnesses in such cases shall be allowed the same compensation as is allowed to witnesses attending the courts of the United States; *Provided*, That no witness shall be required to attend at any place more than forty miles from the place where the subpœna shall be served upon him, to give a deposition under this law: *Provided also*, That no witness shall be deemed guilty of contempt for refusing to disclose any secret invention made or owned by him: *And provided further*, That no witness shall be deemed guilty of contempt for disobeying any subpœna directed to him by virtue of this act, unless his fees for going to, returning from, and one day's attendance at the place of examination shall be paid or tendered to him at the time of the service of the subpœna.

SECTION 2. *And be it further enacted*, That, for the purpose of securing greater uniformity of action in the grant and refusal of letters patent, there shall be appointed by the President, by and with the advice and consent of the Senate, three examiners-in-chief, at an annual salary of three thousand dollars each, to be composed of persons of competent legal knowledge and scientific ability, whose duty it shall be, on the written petition of the applicant for that purpose being filed, to revise and determine upon the validity of decisions made by examiners when adverse to the grant of letters patent; and also to revise and determine in like manner upon the validity of the decisions of examiners in interference cases, and when required by the commissioner in applications for the extension of patents, and to perform such other duties as may be assigned to them by the commissioner; that from their decisions appeals may be taken to the Commissioner of Patents in person, upon payment of the fee hereinafter prescribed; that the said examiners-in-chief shall be governed in their actions by the rules to be prescribed by the Commissioner of Patents.

SECTION 3. *And be it further enacted*, That no appeal shall be allowed to the examiners-in-chief from the decisions of the primary examiners, except in interference cases, until after the application shall have been twice rejected; and the second examination of the application by the primary examiner shall not be had until the applicant, in view of the reference given on the first rejection, shall have renewed the oath of invention, as provided for in the seventh section of the act entitled "An act to promote the progress of the useful arts, and to repeal all acts and parts of acts heretofore made for that purpose," approved July fourth, eighteen hundred and thirty-six.

SECTION 4. *And be it further enacted*, That the salary of the Commissioner of Patents, from and after the passage of this act, shall be four thousand five hundred dollars per annum, and the salary of the chief clerk of the Patent Office shall be two thousand five hundred dollars, and the salary of the librarian of the Patent Office shall be eighteen hundred dollars.

SECTION 5. *And be it further enacted*, That the Commissioner of Patents is authorized to restore to the respective applicants, or when not removed by them, to otherwise dispose of such of the models belonging to rejected applications as he shall not think necessary to be preserved. The same authority is also given in relation to all models

accompanying applications for designs. He is further authorized to dispense in future with models of designs when the design can be sufficiciently represented by a drawing.

SECTION 6. *And be it further enacted*, That the tenth section of the act approved the third of March, eighteen hundred and thirty-seven, authorizing the appointment of agents for the transportation of models and specimens to the Patent Office, is hereby repealed.

SECTION 7. *And be it further enacted*, That the Commissioner is further authorized, from time to time, to appoint, in the manner already provided for by law, such an additional number of principal examiners, first assistant examiners, and second assistant examiners, as may be required to transact the current business of the office with despatch, provided the whole number of additional examiners shall not exceed four of each class, and that the total annual expenses of the Patent Office shall not exceed the annual receipts.

SECTION 8. *And be it further enacted*, That the Commissioner may require all papers filed in the Patent Office, if not correctly, legibly, and clearly written, to be printed at the cost of the parties filing such papers; and for gross misconduct he may refuse to recognise any person as a patent agent, either generally or in any particular case; but the reasons of the Commissioner for such refusal shall be duly recorded, and subject to the approval of the President of the United States.

SECTION 9. *And be it further enacted*, That no money paid as a fee on any application for a patent after the passage of this act shall be withdrawn or refunded, nor shall the fee paid on filing a caveat be considered as part of the sum required to be paid on filing a subsequent application for a patent for the same invention.

That the three months' notice given to any caveator, in pursuance of the requirements of the twelfth section of the act of July fourth, eighteen hundred and thirty-six, shall be computed from the day on which such notice is deposited in the post-office at Washington, with the regular time for the transmission of the same added thereto, which time shall be endorsed on the notice; and that so much of the thirteenth section of the act of Congress, approved July fourth, eighteen hundred and thirty-six, as authorizes the annexing to letters patent of the description and specification of additional improvements, is hereby repealed, and in all cases where additional improvements would now be admissible, independent patents must be applied for.

SECTION 10. *And be it further enacted*, That all laws now in force, fixing the rates of the Patent Office fees to be paid, and discriminating between the inhabitants of the United States and those of other countries, which shall not discriminate against the inhabitants of the United States, are hereby repealed, and in their stead the following rates are established:—

On filing each caveat, ten dollars.

On filing each original application for a patent, except for a design, fifteen dollars.

On issuing each original patent, twenty dollars.

On every appeal from the Examiners-in-Chief to the Commissioner, twenty dollars.

On every application for the re-issue of a patent, thirty dollars.

On every application for the extension of a patent, fifty dollars; and fifty dollars, in addition, on the granting of every extension.

On filing each disclaimer, ten dollars.

For certified copies of patents, and other papers, ten cents per hundred words.

For recording every assignment, agreement, power of attorney, and other papers of three hundred words or under, one dollar.

For recording every assignment, and other papers, over three hundred and under one thousand words, two dollars.

For recording every assignment or other writing, if over one thousand words, three dollars.

For copies of drawings, the reasonable cost of making the same.

* SECTION 11. *And be it further enacted*, That any citizen or citizens, or alien or aliens, having resided one year in the United States and taken the oath of his or their intention to become a citizen or citizens, who by his, her, or their own industry, genius, efforts, and expense, may have invented or produced any new and original design for a manufacture, whether of metal or other material or materials, and original design for a bust, statue, or bas relief, or composition in alto or basso relievo, or any new and original impression or ornament, (or) to be placed on any article of manufacture, the same being formed in marble or other material, or any new and useful pattern, or print, or picture, to be either worked into or worked on, or printed. or painted, or cast, or otherwise fixed on any article of manufacture, or any new and original shape or configuration of any article of manufacture, not known or used by others before his, her, or their invention or production thereof, and prior to the time of his, her, or their application for a patent therefor, and who shall desire to obtain an exclusive property or right therein to make, use, (and sell) and vend the same, or copies of the same, to others, by them to be made, used, and sold, may make application in writing, to the Commissioner of Patents, expressing such desire: and the Commissioner, on due proceedings had, may grant a patent therefor, as in the case now of application for a patent, for the term of three and one-half years, or for the term of seven years, or for the term of fourteen years, as the said applicant may elect in his application: *Provided*, That the fee to be paid in such application shall be, for the term of three years and six months, ten dollars; for seven years, fifteen dollars; and for fourteen years, thirty dollars: *And provided*, That the patentees of designs under this act shall be entitled to the extension of their respective patents, for the term of seven years from the day on which said patents shall expire, upon the same terms and restrictions as are now provided for the extension of letters patent.

SECTION 12. *And be it further enacted*, That all applications for patents shall be completed and prepared for examination within two years after the filing of the petition, and in default thereof, they shall

* This section of the Act originated with, and was drawn up by Mr. H. Howson of this city, whose communicaiton on the subject was published in this Journal, Vol. xxxix, 3d Series, page 265.

be regarded as abandoned by the parties thereto, unless it be shown to the satisfaction of the Commissioner of Patents that such delay was unavoidable; and all applications now pending shall be treated as if filed after the passage of this act; and all applications for the extension of patents shall be filed at least ninety days before the expiration thereof, and notice of the day set for the hearing of the case shall be published, as now required by law, for at least sixty days.

SECTION 13. *And be it further enacted*, That in all cases where an article is made or vended by any person under the protection of letters patent, it shall be the duty of such person to give sufficient notice to the public that said article is so patented, either by affixing thereon the word patented, together with the day and year the patent was granted, or when, from the character of the article patented, that may be impracticable, by enveloping one or more of the said articles, and affixing a label to the package, or otherwise attaching thereto a label on which the notice, with the date, is printed; on failure of which, in any suit for the infringement of letters patent by the party failing so to mark the article the right to which is infringed upon, no damage shall be recovered by the plaintiff, except on proof that the defendant was duly notified of the infringement, and continued after such notice to make or vend the article patented. And the sixth section of the act entitled an "Act in addition to an act to promote the progress of the useful arts," and so forth, approved the twenty-ninth day of August, eighteen hundred and forty-two, be, and the same is hereby, repealed.

SECTION 14. *And be it further enacted*, That the Commissioner of Patents be, and he is hereby, authorized to print, or in his discretion to cause to be printed, ten copies of the description and claims of all patents which may hereafter be granted, and ten copies of the drawings of the same, when drawings shall accompany the patents: *Provided*, The cost of printing the text of said descriptions and claims shall not exceed, exclusive of stationery, the sum of two cents per hundred words for each of the said copies, and the cost of the drawing shall not exceed fifty cents per copy: one copy of the above number shall be printed on parchment, to be affixed to the letters patent: the work shall be under the direction, and subject to the approval, of the Commissioner of Patents, and the expense of the said copies shall be paid for out of the Patent Fund.

SECTION 15. *And be it further enacted*, That printed copies of the letters patent of the United States, with the seal of the Patent Office affixed thereto, and certified and signed by the Commissioner of Patents, shall be legal evidence of the contents of said letters patent in all cases.

SECTION 16. *And be it further enacted*, That all patents hereafter granted shall remain in force for the term of seventeen years from the date of issue; and all extensions of such patents is hereby prohibited.

SECTION 17. *And be it further enacted*, That all acts and parts of acts heretofore passed, which are inconsistent with the provisions of this act, be, and the same are hereby repealed.

*On a new Resistance Thermometer.*—By C. WILLIAM SIEMENS.

From the Lond. Ed. and Dub. Phil. Mag., Jan., 1861.

To Professor John Tyndall, F. R. S., &c., Royal Institution.

MY DEAR SIR,—You will probably be interested to hear about a very direct application of physical science to a purpose of considerable practical importance, which I had lately occasion to make. Having charge, for the British Government, of the Rangoon and Singapore telegraph cable, in so far as its electrical conditions are concerned, I was desirous to know the precise temperature of the coil of cable on board ship at different points throughout its mass, having been led by previous observations to apprehend spontaneous generation of heat. As it would have been impossible to introduce mercury thermometers into the interior of the mass, I thought of having recourse to an instrument based upon the well-ascertained fact that the conductivity of a copper wire increases in a simple ratio inversely with its temperature. The instrument consists of a rod or tube of metal about 18 inches long, upon which silk-covered copper wire is wound in several layers so as to produce a total resistance of, say 1000 (Siemens) units at the freezing temperature of water. The wire is covered for protection with sheet india rubber, inserted into a tube and hermetically sealed. The two ends of the coil of wire are brought, by means of insulated conducting wires, into the observatory, where they are connected to measuring apparatus, consisting of a battery, galvanometer, and variable resistance coil. The galvanometer employed has two sets of coils, traversed in opposite directions by the current of the battery. One circuit is completed by the insulated thermometer coil, and the other by a variable resistance coil of German silver wire. Instead of the differential galvanometer, a regular Wheatstone's bridge arrangement may be employed.

You will readily perceive that if the thermometer coil before described were placed in snow and water, and the variable resistance coil were stoppered so as to present 1000 units of resistance, the currents passing through both coils of the differential galvanometer would equal one another, and produce, therefore, no deflection of the needle. If, however, the temperature of the water should rise, say 1° Fahr., its resistance would undergo an increase $1000 \times \cdot 0021 = 2 \cdot 1$ units of resistance, necessitating an addition of 2·1 units to the variable resistance coil in order to re-establish the equilibrium of the needle.

The ratio of increase of resistance of copper wire with increase of temperature may be regarded as perfectly constant within the ordinary limits of temperature; and being able to appreciate the tenth part of a unit in the variable resistance coil employed, I have the means of determining with great accuracy the temperature of the locality where the thermometer resistance coil is placed. Such thermometer resistance coils I caused to be placed between the layers of the cable at regular intervals, connecting all of them with the same measuring apparatus in the cabin.

After the cable had been about ten days on board (having left a

wet tank on the contractors' works), very marked effects of heat resulted from the indications of the thermometer coils inserted into the interior of the mass of the cable, although the coils nearer the top and bottom surfaces did not show yet any remarkable excess over the temperature of the ship's hold, which was at 60° Fahr. The increase of heat in the interior progressed steadily at the rate of about 3° Fahr. per day, and having reached 86° Fahr., the cable would have been inevitably destroyed in the course of a few days, if the generation of heat had been allowed to continue unchecked.

Considering the comparatively low temperature of the surface of the cable, much incredulity was expressed by lookers-on, respecting the trust-worthiness of these results; but all doubts speedily vanished when large quantities of cold water of 42° temperature were pumped upon the cable, and found to issue 72° Fahr. at the bottom.

Resistance thermometers of this description might, I think, be used with advantage in a variety of scientific observations,—for instance, to determine the temperature of the ground at various depths throughout the year, or of the sea at various depths, &c., &c. In the construction of this instrument, care has to be taken that no sensible amount of heat is generated by the galvanic currents in any of the resistances employed.

By substituting an open coil of platinum wire for the insulated copper coil, this instrument would be found useful also as a pyrometer.

But finding this letter already exceeds its intended limits I shall not enlarge upon these applications, which, no doubt, are quite obvious to you. I am, &c.

December, 1860.

## *French Steam Frigate "La Gloire."*

This is the first steam vessel which was sheathed with iron. It is a magnificent ship, 77 metres (252·74 ft.) long, by 15 metres (49·23 ft.) wide, owing an imposing appearance to the severity of her lines, and her massive cuirass. At a height of 1·82 metres (6 ft.) above the water-line is a battery of 12 heavy guns. Her quarter-deck is fortified with iron, to insure the commander's post. In a quiet sea *La Gloire* divides the water without shock, and so to speak without foam. She has reached a speed of 13·21 knots, with all furnaces lighted; 11 knots, with half furnaces. In a heavy sea she parts the waves with very little pitching, and with a quartering wave, the ease of her roll leaves nothing to be desired.—*Cosmos*, November, 1860.

# AMERICAN PATENTS.

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| Adding Machines, | Joseph Harris, Jr., | Roxbury, | Mass. | 1 |
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| ———,—Setting up | A. G. Mack, . | Rochester, | N. Y. | 1 |
| Baskets,—Manufacture of | Thomas Hegarty, . | St. Louis, | Mo. | 15 |
| Bed Bottom,—Spring | H. L. Thistle, . | City of | N. Y. | 22 |
| Blacking Box Holder, . | J. W. Lewis, . | Providence, | R. I. | 1 |
| Bonnets,—Pressing | H. E. West, . | Attleborough, | Mass. | 29 |
| Boot Legs,—Turning . | A. Ransom, . | Manheim, | N. Y. | 29 |
| Bottles,—Glass Stopper for | S. A. Whitney, . | Glassborough, | N. J. | 1 |
| Bed Bottom, . | J. S. Smith, . | Lowell, | Mass. | 29 |
| Braiding Machines, | G. K. Winchester, | Providence, | R. I. | 1 |
| Brakes,—Adjustable Carriage | J. A. Letts, . | Trumansburg, | N Y. | 29 |
| ———,—Automatic | John Wilkinson, | Baltimore, | Md. | 1 |
| ———,—Car . | W. C. Wright, . | City of | N. Y. | 15 |
| Bread and Pastry Board, | James McNamee, | Easton, | Penna. | 1 |
| Brick Tiles, &c.,—Making | E. G. Oldfield, . | Bordentown, | N. J. | 15 |
| Bridges,—Iron . | Lewis Eikenberry, | Easton, | Penna. | 22 |
| Candle Wicks, . | C. A. Wortendyke, . | Godwinville, | N. J. | 1 |
| Caoutchouc,—Compositions of | R. F. H. Havemann, | N. Brunswick, | " | 29 |
| ——————— | " . | " | " | 29 |
| Carpenters,—Machine for | Wm. R. Axe, . | Beloit, | Wis. | 22 |
| Carriage Bodies,—Hanging | Stringfellow & Surles, | Lumpkin, | Ga. | 15 |
| ——— Seats,—Self-adjusting | John C. Kimball, . | New Haven, | Conn. | 1 |
| Carriages,—Children's | J. A. Crandall, . | City of | N. Y. | 15 |
| Cars,—Stopping and Starting | James Higgin, . | Manchester, | Engl'd, | 8 |
| Carts or Wagons,—Weighing | N. E. Doane, . | Hannibal, | Mo. | 22 |
| Chain Cables,—Link Shackle of | W. J. Hotchkiss, . | Derby, | Conn. | 1 |
| Chimney Top, . | Nicholas Hackett, | Albany, | N. Y. | 1 |
| Clocks,—Winding . | Robert Hitchcock, . | Watertown, | " | 29 |
| Clothes Dryer, . | J. H. Durand, . | Niles, | Mich. | 1 |
| ——— . | C. G. Sargent, . | Chelsea, | Mass. | 29 |
| Cork-cutting Machines, | Alexander Millar, | City of | N. Y. | 29 |
| Corn Planters, . | A. W. Brinkerhoff, . | Up. Sandusky, | Ohio, | 8 |
| ——— . | Wm. Combs, . | Duquoin, | Ill. | 8 |
| ——— . | E. W. Kimball, . | Ottawa, | " | 8 |
| ——— . | J. Y. D. Murphy, | Half Moon, | Penna. | 22 |
| ——— . | W. C. Willey, . | Princeton, | Ill. | 22 |
| —— Shellers, . | C. C. French, . | W. Stockbridge, | Mass. | 15 |
| Cotton Bales,—Iron Ties for | J. J. McComb, . | New Orleans, | La. | 29 |
| ——— Cleaners, . | E. W. Tarpley & others, | Jackson, | Miss. | 1 |
| ——— Gins, . | J. E. Ferguson, . | Micanopy, | Fa. | 1 |
| ——— Pickers, . | John Griffin, . | Louisville, | Ky. | 22 |
| ——— Scrapers, . | J. D. Houston, . | Pope's Depot, | Miss. | 15 |
| Couplings,—Railroad Car | Osgood & Shaw, | Boston, | Mass. | 15 |
| ——————— | Archibald H. Rowand, | Allegheny, | Penna. | 1 |
| ———,—Hose . | Ambrose E. Barnard, | Paterson, | N. J. | 15 |
| Cultivators, . | J. T. D. Alexander, . | Maryenna, | Texas, | 15 |
| ——— . | W. A. Dryden, . | Monmouth, | Ill. | 15 |
| ——— . | E. W. Fuller, . | Martinsville, | La. | 22 |
| ——— . | A. B. Lefler, . | Canton, | Ind. | 22 |
| ——— . | D. S. Stafford, . | Decatur, | Ill. | 15 |
| Curry Combs,—Riveting | B. B. Hotchkiss, | Sharon, | Conn. | 1 |
| ——— . | Sarah Jane Wheeler, | New Britain, | " | 22 |
| Curtain Fixture, . | E. M. Judd, . | " | " | 29 |
| Cutting and Grinding Apparatus, | Purches Miles, . | New Haven, | " | 8 |
| Deck Light, . | Henry Lanergan, | E. Cambridge, | Mass. | 29 |
| Docking Ships, &c.,—Appa's for | J. W. Nystrom, . | St. Petersburg, | Russia, | 15 |
| Dough,—Mixing . | Wm. Hotine, . | Brooklyn, | N. Y. | 8 |
| Dove-tailing Machine, . | King & Norris, . | Lexington, | Ky. | 22 |

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| Draw-bridges, . | Bayley & Nelson, | Brashear, | La. | 29 |
| Drawer Alarms, . | F. H. Purington, . | Willimantic, | Conn. | 22 |
| Evaporating Liquids, | Hathaway & Lathrop, | Detroit, | Mich. | 1 |
| Fabrics Air and Water Tight, | A. C. Teubner, . | City of | N. Y. | 22 |
| Fare Boxes, . | W. B. Bartram, . | Norwalk, | Conn. | 22 |
| ——— . | J. B. Slawson, . | New Orleans, | La. | 29 |
| Fertilizers,—Sowing | John F. Killer, . | Greencastle, | Penna. | 1 |
| Fibrous Material,—Reducing | Reuben Daniels, . | Woodstock, | Vt. | 22 |
| Field Rollers, . | J. C. Pease, . | Sycamore, | Ohio, | 8 |
| Fire Arms,—Breech-loading | Frederick Townsend, | Albany, | N. Y. | 29 |
| ——— | C. O. Wood, . | Worcester, | Mass. | 1 |
| —— Bricks,—Ovens for Baking | L. A. Boisson, . | Lyons, | France, | 22 |
| —— Engine Hose,—Mending | J. S. Mackay, . | Brooklyn, | N. Y. | 15 |
| —— Escapes, . | J. A. Law, . | Meredith, | " | 29 |
| ——— . | J. W. Sprague, . | Rochester, | " | 22 |
| —— Places, . | John McMurtry, . | Fayette co., | Ky. | 22 |
| Gaiters,—Ankle-supporting | T. G. Rich, . | Milton, | Mass. | 29 |
| Gas Regulators, . | C. L. Herring, . | St. Louis, | Mo. | 22 |
| Glass Making,—Pots for | Edward Dithridge, | Pittsburgh, | Penna. | 1 |
| Grain Dryers, . | Samuel Schuyler, . | Brooklyn, | N. Y. | 22 |
| —— Separators, | A. Fanckboner, . | Schoolcraft, | Mich. | 15 |
| ——— . | Ellis Michael, . | La Porte, | Ind. | 8 |
| Gymnastic Apparatuses, | Veerkamp & Leopold, | Philadelphia, | Penna. | 1 |
| Hair Crimpers, . | W. F. George, . | City of | N. Y. | 29 |
| Hat Bodies,—Making | J. F. Greene, . | Brooklyn, | " | 1 |
| Hats,—Finishing . | J. H. La Bau, . | City of | " | 22 |
| Harpoon Guns, . | T. W. Roys, . | Southampton, | " | 22 |
| Harvesting Machines, . | E. H. Wheeler, . | Keokuk, | Iowa, | 29 |
| Harvesters, . | C. G. Dickinson, | Poughkeepsie, | N. Y. | 29 |
| ——— (2 patents) | George Esterly, . | White Water, | Wis. | 22 |
| ——— . | D. S. Morgan, . | Brockport, | N. Y. | 22 |
| ———,—Finger Guards for | M. L. Ballard (4 patents), | Canton, | Ohio, | 29 |
| ——— | Lewis Miller, . | " | " | 29 |
| Hay,—Machines for Gathering | F. F. Fowler, . | Crane towns'p, | " | 22 |
| Hemp Brakes, . | Robert Heneage, | Buffalo, | N. Y. | 22 |
| ——— . | Wm. Jones, . | St. Louis, | Mo. | 29 |
| ——— . | McCormick & Baker, | " | " | 22 |
| Hinge, . | Samuel Ehrman, . | Mount Joy, | Penna. | 29 |
| Hoisting Apparatuses, | E. G. Otis, . | Yonkers, | N. Y. | 15 |
| ——— Devices, . | J. J. Doyle, . | City of | " | 8 |
| Hollow Ware,—Boiled Metallic | Ezra Ripley, . | Troy, | " | 1 |
| Horse Powers, . | Gelston Sanford, . | City of | " | 8 |
| Horses from Interfering, | D. G. Kettell, . | Worcester, | Mass. | 22 |
| ———,—Harness for Shoeing | J. P. Reynolds, . | Mirabile, | Mo. | 22 |
| ———,—Strap for Fastening | D. S. Bartlett, . | Roxbury, | Mass. | 15 |
| Hot Air Pipes,—Evaporator for | G. F. J. Colburn, . | Newark, | N. J. | 22 |
| Hub Machines, . | I. N. Felch, . | Hollis, | Me. | 22 |
| Hydrometers, . | James Adams, . | City of | N. Y. | 15 |
| Ice Crusher, . | John Middleton, | City of | N. Y. | 1 |
| Iron,—Centering Bars of | N. F. Newell, . | Northbridge, | Mass. | 29 |
| ——,—Corrugating | J. S. Vernam, . | Rochester, | N. Y. | 1 |
| ——,—Manufacture of Sheet | D. A. Morris, . | Pittsburgh, | Penna. | 22 |
| —— Pavements,—Constructing | B. C. Smith, . | Burlington, | N. J. | 8 |
| Kettle Handle, . | Joseph Warner, . | New Britain, | Conn. | 22 |
| Knife Cleaner, . | Oliver Sweeney, | Norwich, | " | 22 |
| Knitting Machines, . | Joseph Hollen, . | Fostoria, | Penna. | 1 |
| ——— | John Terrell, . | Philadelphia, | " | 1 |

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| Lamp or Candle Stand, | F. A. Marshall, | Marlborough, | Mass. | 29 |
| —— and Candle Wicks, | Stephen R. Weeden, | Providence, | R. I. | 1 |
| —— Chimneys,—Cleaning | T. B. DeForest, | Birmingham, | Conn. | 15 |
| Lamps, | C. H. Dolbeare, | Boston, | Mass. | 1 |
| ——— | O. C. Evans, | City of | N. Y. | 22 |
| ——— | Henry Leibert, | Norristown, | Penna. | 1 |
| ——— | Emil Trittin, | Philadelphia, | " | 29 |
| ———,—Vapor | C. B. Loveless, | Tom's River, | N. J. | 22 |
| ———— ——— | Levi Short, | Buffalo, | N. Y. | 29 |
| Leather Straps,—Creasing, &c., | W. McK. Thorton, | Niles, | Mich. | 8 |
| Lever Escapement, | Prosper Humbert, | Boston, | Mass. | 1 |
| Light by Frictional Electricity, | Maurice Wesolowski, | City of | N. Y. | 29 |
| Lithographic Stones,—Mounting | G. H. Reynolds, | " | " | 1 |
| Locks, | Titus Powers, | Philadelphia, | Penna. | 29 |
| ——— | S. C. St. John, | Edmeston, | N. Y. | 29 |
| ——— | Linus Yale, Jr., | Philadelphia, | Penna. | 29 |
| Looms,—Hand | J. G. Henderson, | | Mo. | 1 |
| ———,—Harness Motions for | B. F. Knowles, | Providence, | R. I. | 22 |
| Lubricating Journals, Axles, &c., | C. L. Morehouse, | Jackson, | Tenn. | 29 |
| Mattress,—Floating | Wm. Williams, | St. Louis, | Mo. | 1 |
| Meat Cutter, | Purches Miles, | New Haven, | Conn. | 8 |
| Mill Gearing | J. H. Glover, | Glasgow, | Ky. | 8 |
| Millstones,—Dressing | H. B. Weaver, | S. Windham, | Conn. | 15 |
| ———,—Facing & Polishing | Edmund Munson, | Utica, | N. Y. | 29 |
| Mouldings,—Cutting Wooden | A. H. Brown, | Albany, | " | 22 |
| Moulding,—Preparing Patterns | Hanson Wright, | Westford, | " | 1 |
| Neck Ties, | P. F. Smith, | City of | N. Y. | 29 |
| Needles, | George Cooper, | Thompsonville, | Conn. | 22 |
| Newspaper Files, | H. S. White, | Newport, | R. I. | 22 |
| Nut Machines, | Purches Miles, | New Haven, | Conn. | 1 |
| Ordnance,—Breech-loading | L. C. T. Weber, | Rochester, | N. Y. | 1 |
| ————,—Projectiles for | S. C. Abbott, | Zanesville, | Ohio, | 15 |
| Ovens, | Wm. Sellers, | Philadelphia, | Penna. | 22 |
| Oxychloride of Lead, | Ludwig Brumlen, | Hoboken, | N. J. | 29 |
| Paper-making Machinery, | G. J. Wheeler and others, | Bloomfield, | N. J. | 22 |
| Pavement & Railway combined, | B. C. Smith, | Burlington, | " | 15 |
| Pencil Heads,—India Rubber | Arthur Neill, | Boston, | Mass. | 22 |
| Penholders, | Joel Bryant, | Brooklyn, | N. Y. | 29 |
| Photographic Pictures,—Enlarg. | John H. Whitley, | Owego, | " | 1 |
| Picker Staff Motion, | N. S. Bean, | Manchester, | N. H. | 22 |
| Ploughs, | Wm. Jarrell, | Trenton, | Tenn. | 22 |
| ——— | G. H. Moore, | Rochester, | N. Y. | 1 |
| ——— | Jeremiah Sweitzer, | Mishawka, | Ind. | 22 |
| ——— | Lorenz Wolfe, | Hamburg, | Mo. | 15 |
| ———,—Covering | Washington Roberts, | Rocheport, | " | 15 |
| ———,—Mole | Homer Gillet, | Lyndon, | Ill. | 15 |
| ———,—Seeding | W. P. Penn, | Belleville, | " | 15 |
| ———,—Shields to | J. F. Cameron, | Bedford, | Mo. | 15 |
| ———,—Sub-soil | " | " | " | 15 |
| Preserve Cans, | N. S. Gilbert, | Lockport, | N. Y. | 29 |
| Presses,—Cotton | Isaac Griffin, | Milford, | Ga. | 8 |
| Pumps, | Albert Bellingrath, | Atlanta, | " | 22 |
| Railroad Chairs, | E. B. Banker, | Schaghticoke, | N. Y. | 8 |
| ————————— | Enoch Weight, | Charlestown, | Mass. | 29 |
| ——— Cars,—Stop. & Start. | Peter Louis, | City of | N. Y. | 15 |
| ———————————— | Bernard Morohan, | Brooklyn, | " | 15 |
| ——— Stations, &c.,—Indica. | H. H. Gratz, | Spring Station, | Ky. | 29 |
| Railway Tire,—Rolling | S. Jaqua, | Paterson, | N. J. | 29 |
| Ranges,—Cooking | James Ingram, | City of | N. Y. | 8 |

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| Reaping Machines,—Rakes for | George Esterly, . | Whitewater, | Wis. | 15 |
| Reapers,—Rakes for . | M. C. Brelsford, . | Girard, | Ill. | 15 |
| Refrigerator, . | B. J. Burnett, . | Mt. Vernon, | N. Y. | 1 |
| ——— . | John C. Schooley, . | Cincinnati, | Ohio, | 1 |
| Roots,—Cutting . | W. C. Berry, . | Woodbridge, | N. J. | 1 |
| Saccharine Juices,—Evaporating | Wm. Chesterman, . | Peosta, | Iowa, | 22 |
| Sad Iron, . | P. D. Van Hoesen, | City of | N. Y. | 8 |
| Sash Fastener, . | Wm. B. Barnard, . | Waterbury, | Conn. | 29 |
| Sausage Stuffer, . | August Nettinger, Jr., | Philadelphia, | Penna. | 1 |
| Sawing Machines,—Circular | W. H. Auld, . | Fairfield, | Iowa, | 22 |
| Saws,—Straining Wood | Abijah Fessenden, | Boston, | Mass. | 29 |
| ——— . | James Haynes, . | Hollis, | Me. | 1 |
| Saw Teeth, . | I. S. Brown, . | Hopkinton, | R. I. | 8 |
| Scales, . | S. S. Hitchcock, . | Chicago, | Ill. | 29 |
| Scissors, . | John Reist, . | Philadelphia, | Penna. | 1 |
| Screws,—Cutting, &c., . | Bennett & Dalzell, . | Waddington, | N. Y. | 22 |
| Seed Drills, . | J. H. Bean, . | Forreston, | Ill. | 15 |
| —— Planters,—Cotton . | L. B. Brown, . | Scriven co., | Ga. | 15 |
| ——— | Daniel Herlong, | Sandy Ridge, | Ala. | 15 |
| Seeding Cultivators, . | Goodman & Rote, . | Lancaster, | Penna. | 15 |
| —— Machines, | C. Eggelston, . | Beloit, | Wis. | 1 |
| ——— . | Lee & Reese, . | Phillipsburgh, | N. J. | 1 |
| ——— | David Pardee, . | Carlyle, | Ill. | 8 |
| ——— . | W. P. Penn, . | Belleville, | " | 8 |
| ——— | W. B. Quarton, . | Carlinville, | " | 8 |
| Sewing Machines, . | F. D. Ballou, . | Abington, | Mass. | 22 |
| ——— | J. T. Bruen, . | Brooklyn, | N. Y. | 22 |
| ——— . | Thomas Earle, . | Worcester, | Mass. | 22 |
| ——— | Charles Irwin, . | Buffalo, | N. Y. | 22 |
| ——— . | Johnson & Bartlett, . | Boston, | Mass. | 22 |
| ——— | S. W. Langdon, | Northampton, | " | 22 |
| ——— . | Quartus Rice, . | Nevada, | Cal. | 22 |
| ——— | J. C. Smith, . | Troy, | N. Y. | 29 |
| ———,—Treadles | Warren Glover, . | N. Eng. Village, | Mass. | 29 |
| Shingle Machines, | P. H. Woolsey, . | Andes, | N. Y. | 29 |
| Shingles,—Sawing . | A. F. French, . | Franklin, | Vt. | 29 |
| Shoes and Boots,—Gum | Louis Bauhoefer, | Philadelphia, | Penna. | 22 |
| Shrouds of Ships,—Attaching | John Taber, . | Bangor, | Me. | 1 |
| Shutters,—Rolling Iron | G. F. Letz, . | Chicago, | Ill. | 29 |
| Sieves, . | A. E. and J. B. Blood, | Lynn, | Mass. | 22 |
| Signalizing, . | A. J. Meyer, . | Buffalo, | N. Y. | 29 |
| Skate Fastenings, . | J. B. Gibbs, . | Boston, | Mass. | 29 |
| Skates, . | Alfred Hathaway, | Charlestown, | " | 1 |
| ——— . | H. W. Warner, . | Greenfield, | " | 1 |
| Skating Boots, . | Pearson & Peabody, | Winchester, | " | 1 |
| Skirts,—Sides for Hoop . | Henry Scheuerle, . | City of | N. Y. | 1 |
| Soaps,—Castor Oil | T. D. Mathews, . | St. Peter's Par. | S. C. | 1 |
| Springs for Railroad Cars, | T. F. Allen, . | Dyersville, | Iowa, | 15 |
| Spoke Machines,—Mechanism | Eliakim Briggs, | South Bend, | Ind. | 1 |
| Staging,—Steamboat . | A. John Bell, . | Ashland, | Ky. | 22 |
| Stave Jointer, . | Gabrion & Whitney, | Copenhagen, | N. Y. | 22 |
| —— Machines, . | E. and B. Holmes, . | Buffalo, | " | 22 |
| Steam Cylinders,—Relieving | G. W. Furman, . | Brooklyn, | " | 15 |
| —— Engines, . | N. S. Bean, . | Manchester, | N. H. | 15 |
| ——— . | Tisdale Carpenter, | Providence, | R. I. | 29 |
| ——— . | P. L. Weimer, . | Lebanon, | Penna. | 29 |
| —— Hammers, | R. R. Taylor, . | Reading, | " | 1 |
| —— Pressure Gauge, . | Wm. Burnett, . | Boston, | Mass. | 29 |
| Stilts, . | Josee Johnson, . | City of | N. Y. | 22 |
| Stove Lining, . | Snider & Gorton, . | Yorkville, | " | 29 |
| Stove and Air-heating Furnace, | P. J. Ackerman, | Paterson, | N. J. | 22 |
| Stoves,—Cooking . | J. G. Treadwell, . | Albany, | N. Y. | 22 |

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| Straw Cutters, | Wm. Newbury, | Clarksville, | Mo. | 1 |
| Stump Extractors, | Davis & Punchus, | Elkhart, | Ind. | 29 |
| Table Fan, | A. R. Traber, | St. Martinsville, | La. | 29 |
| Thills to Axles,—Connecting | W. H. Saunders, | Hastings, | N. Y. | 8 |
| Time Detector,—Watchman's | John Burk, | Schwenningen, | Germ'y, | 1 |
| Tire Heater, | Alfred Ingalls, | Independence, | Iowa, | 22 |
| Tobacco,—Drying | W. B. Hix, | Rome, | Ga. | 8 |
| Tomatoes,—Spirituous Liquors | Wm. Schilling, | Baltimore, | Md. | 1 |
| Tool Handles, | L. C. Rodier, | Springfield, | Mass. | 22 |
| Tools,—Polishing | T. J. Mayall, | Roxbury, | " | 22 |
| Trunk Locks, | E. L. Gaylord, | Terrysville, | Conn. | 29 |
| Tucking Gages, | G. C. Munson, | City of | N. Y. | 22 |
| Type Cases, | Thomas N. Rooker, | " | " | 1 |
| Valve Motion for St'm Engines, | J. H. Dialogue, | Camden, | N. J. | 1 |
| Valves,—Slide | Braidwood & Whiting, | Mt. Vernon, | N. Y. | 15 |
| Veneer Planer, | George Williamson, | Newark, | N. J. | 1 |
| Wagon,—Dumping | John Wilkinson, | Baltimore, | Md. | 15 |
| Watches, | A. L. Dennison, | Waltham, | Mass. | 1 |
| Washing Machine, | J. M. Bois, | Aurora, | N. Y. | 29 |
| Water Elevators, | J. M. Connel, | Newark, | Ohio, | 1 |
| ——— Meters, | F. G. Johnson, | Brooklyn, | N. Y. | 1 |
| ——— Wheels, | G. W. Armstrong, | Clinton, | N. C. | 29 |
| ——————— | Joel Harris, | New Carlisle, | Ind. | 29 |
| Wearing Apparel,—Pockets of | Fenner Darling, | N. Blackstone, | Mass. | 29 |
| Windmills, | Willis Holmes, | Macomb, | Ill. | 15 |
| ——— | G. H. Reister, | Washington, | Iowa, | 15 |
| Window Sashes, | E. P. Carter, | China, | N. Y. | 8 |
| ——— Stop and Fastener, | Clark Shaw, | East Aurora, | " | 29 |
| Wood-bending Machines, | Hiram McDonald, | Union Springs, | " | 22 |
| Wool,—Drawing and Twisting | J. T. Plummer, | Plainfield, | Conn. | 1 |
| Wrench, | Ezra Ripley, | Troy, | N. Y. | 1 |
| Wrenches,—Screw | L. and A. G. Coes, | Worcester, | Mass. | 8 |

ADDITIONAL IMPROVEMENTS.

| | | | | |
|---|---|---|---|---|
| Boots & Shoes,—Metallic Heels | J. V. Dinsmore, | Auburn, | Me. | 15 |
| Gate, | Jasper Johnson, | Genesee, | N. Y. | 29 |
| Refrigerator, | Wm. M. Baker, | Walpole, | Ind. | 15 |

RE-ISSUES.

| | | | | |
|---|---|---|---|---|
| Buildings,—Seats for Public | A. H. Allen, | Boston, | Mass. | 15 |
| Candles,—Moulding (2 pat's) | Willis Humiston, | Troy, | N. Y. | 22 |
| Clothes Wringer, | Elliot Dickerman, | Richmond, | Vt. | 8 |
| Gate, | Jasper Johnson, | Genesee, | N. Y. | 8 |
| Grain Cradles, | M. R. Flanders, | Parishville, | " | 8 |
| ——— Separators, | J. A. Vaughn, | Cuyahoga Falls, | Ohio, | 8 |
| Guns,—Magazine | E. H. Graham, | Manchester, | N. H. | 8 |
| Harvesters, | S. and J. H. Barley, | Longwood, | Mo. | 22 |
| ————— | John Gore, | Brattleboro', | Vt. | 15 |
| ————— (2 pat's) | Palmer & Williams, | Brockport, | N. Y. | 1 |
| —————,—Grain and Grass | Brown & Bartlett, | Woonsocket, | R. I. | 1 |
| —————,—Grass (4 pat's) | J. S. and D. Lake, | Smith Landing, | N. J. | 1 |
| Passenger Cars,—St'm Engs. for | Robert H. Long, | Philadelphia, | Penna. | 15 |
| Presses,—Tobacco (2 pat's) | Wm. Cameron, | Petersburg, | Va. | 15 |
| ————— | Lindsay & Cameron, | " | " | 15 |
| Pulp Machines, | Henry Keney and others, | Hartford, | Conn. | 1 |
| Steam Engines, (2 pat's) | F. E. Sickels, | City of | N. Y. | 1 |
| Teeth,—Porcelain | J. W. Moffitt, | Harrisburg, | Penna. | 8 |
| Threshing Machines, | D. S. Wagener, | Penn Yan, | N. Y. | 29 |
| Valves of St'm Engs., (2 pat's) | F. E. Sickels, | City of | " | 1 |

## FRANKLIN INSTITUTE.

*Proceedings of the Stated Monthly Meeting, March* 21, 1861.]

John C. Cresson, President, in the chair.
John Agnew, Vice President.
John F. Frazer, Treasurer. } Present.
Isaac B. Garrigues, Recording Secretary.

The minutes of the last meeting were read and approved.

Donations to the Library were received from the Royal Astronomical Society, London; la Société Industrielle de Mulhouse, and l'Ecole des Mines, Paris, France; Prof. A. Dallas Bache, Superintendent U. S. Coast Survey, Washington, D. C.; B. H. Latrobe, Esq., Baltimore, Md.; the Cooper Union, City of New York; the Board of Water Commissioners, Detroit, Michigan; the Longview Asylum for the Insane, Columbus, Ohio; the Pennsylvania Institution for the Blind, H. M. P. Birkenbine, Esq., Messrs. Merrick & Sons, Horatio Hubbell, Esq., Henry Howson, Esq., and Professors John C. Cresson and John F. Frazer, Philadelphia.

The Periodicals received in exchange for the Journal of the Institute, were laid on the table.

The Treasurer read his statement of the receipts and payments for the month of February.

The Board of Managers and Standing Committees reported their minutes.

Candidates for membership in the Institute (5) were proposed, and the candidates proposed at the last meeting (5) duly elected.

The Actuary reported that the following Standing Committees have organized by electing their Chairman, and appointing their times for meeting, viz:

| *Committee.* | *Chairman.* | *Time of Meeting.* |
|---|---|---|
| On Library, | George Erety, | 1st Tuesday evening. |
| " Exhibitions, | John E. Addicks, | 1st Thursday " |
| " Cabinet of Models, | John L. Perkins, | 2d Monday " |

Dr. Rand exhibited a specimen of fabric woven from the so-called "Fibrillia." This is prepared from flax, hemp, &c., by exposing the material to high pressure steam, and allowing it suddenly to escape into the air, by which the fibres are disintegrated and form a cotton-like mass.

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## METEOROLOGY.

For the Journal of the Franklin Institute.

*The Meteorology of Philadelphia.* By James A. Kirkpatrick, A.M.

February.—The month of February of this year was the warmest for the last ten years, with the exception of February, 1857, which

was about half a degree warmer. The mean temperature for the month, as will be seen by the accompanying table, was seven degrees higher than that of February, 1860, and nearly six degrees higher than the average for the last ten years.

The 28th of the month was the warmest day, its mean temperature being 56·2°. The thermometer reached its maximum (68½°) on the same day. The coldest day of the month was the 8th, the mean temperature being 8·2°. The minimum (—1°) was reached on the same day. The only time on my record besides this on which the temperature fell below zero in February, was the year 1855, when it marked one degree below, on the 7th of the month, during a heavy snow-storm. The mean temperature of the 7th of February, 1855, was 5·7°.

On the 7th of the month, a severe snow-storm occurred in Canada, and extended throughout New England and northern New York, accompanied by a heavy north-west gale. The wind storm extended from Quebec to the southern boundary of Virginia, and as far west as Buffalo. At Philadelphia, it commenced to rain at 1½ P. M., the wind from the S. S. W. At 2¼ P. M., the rain changed to snow, which fell for about fifteen minutes. At 3 P. M., the wind changed to the north-west, and became very strong. The gale continued all night, and until the afternoon of the next day, doing considerable damage.

The sudden change of temperature during this storm was very remarkable. At 7 A. M. on the 7th, the temperature was 36½°; at 2 P. M., 41°; at 9 P. M. 6°; a difference in seven hours of 35°. At 6 A. M., on the 8th, the temperature was 1° below zero; at 7, it was at zero; at 2 P. M., 10° above zero; at 9 P. M., 14½°.

On the 15th of the month, a heavy shower of rain fell, accompanied, about 2 P. M., by thunder and lightning—the first observed this year.

The temperature was below the freezing point on twelve days of the month; but it rose above that point some time during every day, except on the 8th, when the highest point attained was 16°.

The mean daily range and daily oscillation of temperature were both greater than usual.

The pressure of the atmosphere was greatest (30·485 inches) on the morning of the 9th, and least (29·308 inches) on the afternoon of the 7th. The mean pressure was greatest on the 9th, and least on the 15th of the month. The mean daily range or average of changes of pressure, was four-hundredths of an inch greater than usual.

Snow fell on only two days of the month: that is, on the 7th and 20th. The amount of rain and melted snow for the month (2·124 inches) was the smallest quantity for this month since 1857, and was half an inch less than the average for the last ten years

The force of vapor was greater, and the relative humidity less, than usual, as will appear more particularly in the following table of comparisons.

*A Comparison of some of the Meteorological Phenomena of* FEBRUARY, 1861, *with those of February,* 1860, *and of the same month for ten years, at Philadelphia.*

| | Feb., 1861. | Feb., 1860. | Feb., 10 years. |
|---|---|---|---|
| Thermometer.—Highest, | 68·5° | 70·0° | 70·0° |
| " Lowest, | —1·0 | 1.0 | —1·0 |
| " Daily oscillation, | 17·27 | 17·80 | 13·65 |
| " Mean daily range, | 8·90 | 8·80 | 7·46 |
| " Means at 7 A. M., | 33·86 | 27·24 | 29·22 |
| " " 2 P. M., | 45·55 | 38·07 | 38·68 |
| " " 9 P. M., | 39·14 | 31·69 | 33·55 |
| " " for the month, | 39·52 | 32·33 | 33·82 |
| Barometer.—Highest, | 30·485 in. | 30·358 in | 30·638 in. |
| " Lowest, | 29·308 | 29·099 | 29·065 |
| " Mean daily range, | ·264 | ·209 | ·220 |
| " Means at 7 A. M., | 29·954 | 29 970 | 29·919 |
| " " 2 P. M., | 29·912 | 29·885 | 29 871 |
| " " 9 P. M., | 29·951 | 29·918 | 29 901 |
| " " for the month, | 29·939 | 29·924 | 29·897 |
| Force of Vapor.—Means at 7 A. M., | ·158 in. | ·124 in. | ·140 in. |
| " " " 2 P. M., | ·169 | ·154 | ·166 |
| " " " 9 P. M., | ·186 | ·150 | ·162 |
| Relative Humidity.—Means at 7 A. M., | 75 per ct. | 74 per ct. | 79 per ct. |
| " " " 2 P. M., | 52 | 59 | 64 |
| " " " 9 P. M., | 70 | 72 | 77 |
| Rain and melted snow, | 2·124 in. | 2·724 in. | 2·669 in. |
| No. of days on which rain or snow fell, | 9 | 8 | 10 |
| Prevailing winds, | s 77° 6′ w ·354 | n 61°52′ w ·298 | n 72°12′ w ·303 |

WINTER.—The winter of 1860–61 was one degree warmer than the average winter temperature for the last ten years, and more than one degree warmer than the winter of last year.

The warmest day was the 28th of February, of which the mean temperature was 56·2°. The coldest day was the 13th of January, mean temperature 7·8°. The highest degree ($68\frac{1}{2}$) was reached on the 28th of February, and the lowest (—1) on the 8th of the same month.

The pressure of the atmosphere was nearly two-hundredths of an inch greater than the average winter pressure for the last ten years. This increase was greater at 2 P. M. than at the other hours of observation.

The force of vapor was less at 2 P. M. and greater at 9 P. M. than usual, but the average for the winter was almost precisely the same as for the preceding winter, and but three-thousandths of an inch less than the average for ten years. The relative humidity was also remarkably near that of the preceding year, though the average for the winter was two per cent. less than the winter average for the whole time of observation.

Rain fell on thirty days to the aggregate depth of 10·045 inches, which is about half an inch above the average.

The prevailing winds during this winter came from a point about two degrees north of their direction for the winter of 1859–60; and about the same distance south of their average direction for ten years.

*A Comparison of the* WINTER *of* 1860-61, *with that of* 1859-60, *and of the same season for ten years, at Philadelphia.*

| | Winter. 1860–61. | Winter. 1859–60. | Winter. for 10 years. |
|---|---|---|---|
| Thermometer.—Highest, . . . . | 68·5° | 71·0° | 71.0° |
| " Lowest, . . . | —1·0 | 1·0 | —5·5 |
| " Daily oscillation, . | 13·69 | 15·60 | 12·53 |
| " Mean daily range, . | 6·63 | 7·90 | 6·89 |
| " Means at 7 A. M., . | 30·28 | 28·93 | 29·39 |
| " " 2 P. M., . | 38·51 | 37·64 | 37·56 |
| " " 9 P. M., . | 33·95 | 32·18 | 32·93 |
| " " for the winter, | 34·25 | 32·91 | 33·29 |
| Barometer.—Highest, . . . . | 30·526 in. | 30·399 in. | 29·704 in. |
| " Lowest, . . . . | 29·285 | 29·099 | 28·941 |
| " Mean daily range, . . | ·230 | ·189 | ·213 |
| " Means at 7 A. M., . | 29·961 | 29·960 | 29·950 |
| " " 2 P. M., . . | 29·925 | 29·902 | 29·909 |
| " " 9 P. M., . | 29·959 | 29·929 | 29·935 |
| " " for the winter, | 29·949 | 29·930 | 29·932 |
| Force of Vapor.—Means at 7 A. M., | ·139 in. | ·136 in. | ·138 in. |
| " " " 2 P. M., . | ·151 | ·156 | ·162 |
| " " " 9 P. M., | ·155 | ·150 | ·153 |
| Relative Humidity.—Means at 7 A. M., | 78 per ct. | 77 per ct. | 79 per ct. |
| " " " 2 P. M., | 63 | 63 | 67 |
| " " " 9 P. M., | 74 | 74 | 76 |
| Rain and melted snow, . . . . | 10·045 in. | 9·535 in. | 9·646 in. |
| No. of days on which rain or snow fell, | 30 | 26 | 30 |
| Prevailing winds, . . . . . | N 65°37′ W ·354 | N 67°50′ W ·289 | N 63°31′ W ·308 |

*Abstract of Meteorological Observations for January,* 1861; *for the County of Philadelphia, Pennsylvania.*

PHILADELPHIA.—Lat. 39° 57′ 28″ N. Long. 75° 10′ 28″ W. Height above the sea 50 feet.
Prof. J. A. KIRKPATRICK, Observer.

| 1861. Jan. | Barometer. Mean. | Barometer. Mean daily range. | Thermometer. Mean. | Thermometer. Daily oscillation. | Thermometer. Mean daily range. | Force of vapor. 2 P.M. | Relative humidity. 2 P.M. | Rain and snow. | Prevail'g winds. |
|---|---|---|---|---|---|---|---|---|---|
| | Inch. | Inch. | ° | ° | ° | Inch. | Per ct. | Inch. | Direc. |
| 1 | 30·235 | ·079 | 26·3 | 19 | 7·7 | ·143 | 79 | | N W. |
| 2 | 30·046 | ·189 | 32·0 | 16 | 5·7 | ·164 | 71 | 1·278 | S W. |
| ☾ 3 | 29·673 | ·373 | 35·8 | 6 | 4·8 | ·184 | 85 | 0·025 | N N E. |
| 4 | 29·953 | ·280 | 32·5 | 7 | 3·3 | ·144 | 75 | 0·021 | N W. |
| 5 | 30·174 | ·221 | 32·0 | 13 | 3·2 | ·181 | 80 | | W. |
| 6 | 30·134 | ·086 | 35·0 | 13 | 3·0 | ·115 | 47 | | S W. |
| 7 | 29·751 | ·389 | 41·7 | 10½ | 6·7 | ·226 | 76 | 0·065 | S W. |
| 8 | 29·872 | ·142 | 41·2 | 8 | 2·8 | ·184 | 66 | | W. |
| 9 | 29·752 | ·220 | 35·2 | 5 | 6·0 | ·169 | 80 | 0·567 | S E. |
| ● 10 | 29·604 | ·237 | 31·8 | 8 | 3·3 | ·141 | 69 | | N E. |
| 11 | 29·945 | ·341 | 21·7 | 13 | 10·2 | ·101 | 86 | 0·048 | N W. |
| 12 | 29·964 | ·178 | 20·3 | 17 | 8·0 | ·111 | 76 | 0·039 | N W. |
| 13 | 30·424 | ·460 | 7·8 | 11 | 12·5 | ·049 | 69 | | N N W |
| 14 | 30·160 | ·264 | 22·5 | 22 | 14·7 | ·111 | 87 | 0·404 | N N E. |
| 15 | 29·848 | ·312 | 34·3 | 6½ | 11·8 | ·184 | 85 | 0·476 | N N W |
| 16 | 29·558 | ·290 | 38·2 | 6 | 3·8 | ·225 | 91 | | (var.) |
| 17 | 29·902 | ·344 | 41·5 | 13 | 3·3 | ·166 | 53 | | W. |
| ☽ 18 | 29·930 | ·218 | 35·7 | 8 | 6·2 | ·190 | 90 | 0·270 | S E. |
| 19 | 29·713 | ·226 | 39·3 | 17½ | 4·0 | ·146 | 44 | | (var.) |
| 20 | 29·869 | ·157 | 34·5 | 12 | 6·8 | ·094 | 40 | | W. |
| 21 | 30·081 | ·212 | 30·7 | 12 | 3·8 | ·095 | 45 | | W N W |
| 22 | 30·393 | ·315 | 25·7 | 11½ | 5·0 | ·129 | 78 | | N W. |
| 23 | 30·183 | ·095 | 25·2 | 11 | 1·2 | ·117 | 72 | | (var.) |
| 24 | 29·967 | ·516 | 34·2 | 14 | 9·3 | ·207 | 90 | 0·917 | N E. |
| 25 | 30·009 | ·188 | 36·0 | 4½ | 3·2 | ·142 | 62 | | W N W |
| ○ 26 | 30·048 | ·071 | 28·0 | 9 | 8·0 | ·153 | 100 | 0·510 | N W. |
| 27 | 29·989 | ·060 | 26·2 | 12 | 3·8 | ·145 | 84 | | N W. |
| 28 | 29·964 | ·058 | 29·3 | 12½ | 3·2 | ·138 | 70 | | W. |
| 29 | 29·781 | ·183 | 34·8 | 10 | 5·5 | ·151 | 60 | | S W. |
| 30 | 29·867 | ·241 | 27·8 | 12 | 9·7 | ·087 | 58 | | W N W |
| 31 | 30·004 | ·160 | 23·0 | 11 | 4·8 | ·085 | 58 | | W. |
| Means | 29·971 | ·229 | 31·0 | 11½ | 6·0 | ·144 | 72 | 4·620 | N 52° W |

*Abstract of Meteorological Observations for January,* 1861 ; *made in Franklin, Somerset, Bradford, and Centre Counties, Pennsylvania, for the Committee on Meteorology of the Franklin Institute.*

| 1861. | CHAMBERSBURG, Franklin Co. Lat. 39° 58′ N. Long. 77° 45′ W. Height 618 ft. WM. HEYSER, Jr., Observer. | | | | | | | SOMERSET, Somerset Co. Lat. 40° N. Long. 79° 3′ W. Height 2195 feet. GEO. MOWRY, Observer. | | | | | | | TOWANDA, Bradford Co. 41° 47′ N. 76° 34′ W. Height, ab't 840 ft. S. J. COFFIN, Obs. | | | | FLEMING, Centre Co. 40° 55′ N. 77° 53′ W. Ht., 780 feet. S. BRUGOER, Obs. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Barom. | Thermom. | | Force of vapor. | Relative humidity. | Rain and snow. | Prevail'g winds. | Barom. | Thermom. | | Force of vapor. | Relative humidity. | Rain and snow. | Prevail'g winds. | Barom. | Thermom. | | Prevail'g winds. | Thermom. | | Rain and snow. | Prevail'g winds. |
| Jan. | Mean. | Mean. | Mean daily range. | 2 P.M. | 2 P.M. | | | Mean. | Mean. | Mean daily range. | 2 P.M. | 2 P.M. | | | Mean. | Mean. | Mean daily range. | | Mean. | Mean daily range. | | |
| | Inch. | ° | ° | Inch. | Per ct. | Inch. | Direc. | Inch. | ° | ° | Inch. | Per ct. | Inch. | Direc. | Inch. | ° | ° | Direc. | ° | ° | Inch. | Direc. |
| 1 | 29·599 | 13·0 | 9·0 | ·123 | 90 | | W. | 27·879 | 27·7 | 8·7 | ·129 | 58 | | W S W | | 29.7 | | N W. | 11·0 | 4·3 | | W. |
| 2 | 29·427 | 26·0 | 13·0 | ·186 | 81 | 0·622 | (var.) | 27 681 | 38·7 | 11·0 | ·185 | 51 | 0·252 | W S W | 29·077 | 37·3 | 7·7 | (var.) | 26·0 | 15·0 | | E. |
| ☾ 3 | 29·138 | 36·0 | 10·0 | ·203 | 82 | | N E. | 27·461 | 35·3 | 8·0 | ·177 | 66 | | W. | 28·887 | 27·3 | 12·0 | (var.) | 35·3 | 9·3 | } 0·200 | E. |
| 4 | 29·375 | 31·7 | 6·3 | ·067 | 34 | | W. | 27·631 | 25·0 | 10·3 | ·134 | 87 | 0·047 | W. | 29·050 | 24·7 | 4·0 | N W. | 27·7 | 7·7 | | W. |
| 5 | 29 609 | 29·7 | 7·3 | ·162 | 80 | | W. | 27·846 | 24·7 | 3·7 | ·147 | 78 | | W. | 29·230 | 26·0 | 3·3 | N. | 24·3 | 4·7 | | W. |
| 6 | 29·533 | 29·0 | 6·7 | ·142 | 70 | } 0·233 | E. | 27·746 | 33·0 | 10·3 | ·177 | 66 | 0·220 | W S W | 29·163 | 32·0 | 6·0 | (var.) | 28·3 | 14·0 | | W. |
| 7 | 29·173 | 40·7 | 11·7 | ·195 | 68 | | (var.) | 27·458 | 44·0 | 11·0 | ·242 | 74 | | W S W | 28·790 | 45·7 | 13·7 | S. | 35·0 | 9·3 | 0·100 | E. |
| 8 | 29·317 | 38·3 | 1·7 | ·126 | 49 | | W. | 27·630 | 31·3 | 12·7 | ·140 | 78 | | W N W | 29·013 | 30·0 | 15·7 | N. | 34·3 | 1·3 | | N W. |
| 9 | 29·159 | 35·3 | 3·0 | ·157 | 71 | 0·300 | (var.) | 27·450 | 32·3 | 1·0 | ·196 | 100 | 0·091 | ? | 28·843 | 32·3 | 3·7 | (var.) | 35·0 | 2·7 | 0·100 | E. |
| ● 10 | 29·004 | 30·0 | 5·3 | ·129 | 61 | | W. | 27·404 | 22·7 | 9·7 | ·122 | 86 | 0·279 | (var.) | 28·693 | 25·3 | 8·3 | W. | 23·0 | 12·0 | | W. |
| 11 | 29·287 | 18·7 | 11·3 | ·101 | 86 | 0·200 | (var.) | 27·540 | 23·7 | 12·3 | ·162 | 84 | 0·190 | S W. | 28·953 | 16·0 | 11·3 | N. | 16·0 | 10·3 | } 0·500 | W. |
| 12 | 29·320 | 24·7 | 9·3 | ·085 | 43 | | W. | 27·586 | 29·3 | 8·3 | ·108 | 65 | 0·080 | (var.) | 29·080 | 9·7 | 12·3 | N W. | 17·7 | 7·7 | | (var.) |
| 13 | 29·804 | 5·3 | 19·3 | ·040 | 58 | | E. | 27·925 | 11·0 | 17·7 | ·074 | 60 | | (var.) | 29·477 | 2·3 | 10·0 | (var.) | —6·0 | 23·7 | | W. |
| 14 | 29·539 | 19·0 | 13 7 | ·085 | 72 | } 0·836 | (var.) | 27·730 | 30·7 | 19·3 | ·185 | 86 | 0·362 | S. | 29·197 | 21·7 | 19·3 | (var.) | 16·7 | 22·7 | 0·620 | E. |
| 15 | 29·223 | 33·0 | 14·0 | ·149 | 70 | | E. | 27 531 | 41·0 | 10·3 | ·275 | 92 | 0·456 | ? | 28·937 | 32·0 | 10·3 | (var.) | 32·3 | 15·7 | | E. |
| 16 | 28·971 | 38·7 | 5·7 | ·181 | 73 | | W. | 27·283 | 37·7 | 4·0 | 262 | 84 | 0·083 | (var.) | 28·603 | 39·3 | 7·3 | (var.) | 37·3 | 7·7 | } 0·485 | W. |
| 17 | 29·382 | 37·0 | 3·0 | ·144 | 63 | | W. | 27·697 | 29·3 | 8·3 | ·127 | 76 | | W. | 28·990 | 36·7 | 2·7 | S. | 36 7 | 6·7 | | N W. |
| ☽ 18 | 29·272 | 34·0 | 3·0 | ·142 | 70 | 0·195 | E. | 27·548 | 32·3 | 4·3 | ·154 | 84 | | W S W | 28·940 | 33·3 | 5·3 | S. | 35·3 | 2·7 | 0·100 | E. |
| 19 | 29·101 | 39·0 | 5·0 | ·129 | 46 | | W. | 27 514 | 34·7 | 6·3 | ·155 | 58 | | W. | 28·777 | 37·0 | 5·0 | (var.) | 34·0 | 2·0 | | N W. |
| 20 | 29·322 | 32·0 | 7·0 | ·157 | 71 | | W. | 27·674 | 25·3 | 9·3 | ·075 | 43 | | W. | 28·937 | 28·0 | 5·7 | W. | 26·0 | 8·0 | | N W. |
| 21 | 29·369 | 30·7 | 2·0 | ·173 | 73 | | W. | 27·844 | 21·7 | 3·7 | ·109 | 69 | | (var.) | 29·190 | 22·0 | 6·0 | N W. | 20·7 | 5·3 | | W. |
| 22 | 29·826 | 24·3 | 5·3 | ·049 | 25 | | W. | 28·069 | 17·3 | 5·7 | ·084 | 60 | | N W. | 29·530 | 14·7 | 7·3 | N W. | 13·3 | 7·3 | | W. |
| 23 | 29·875 | 25·0 | 2·3 | ·078 | 46 | | E. | 28·050 | 22·7 | 5·3 | ·083 | 52 | } 0·468 | S E. | 29·607 | 16·0 | 6·0 | (var.) | 18·3 | 5·7 | | E. |
| 24 | 29·359 | 30·0 | 5·0 | ·047 | 25 | 0·400 | E. | 27·639 | 31·3 | 8·7 | ·183 | 90 | | (var.) | 29·063 | | | S E. | 32·0 | 13·7 | 0·650 | E. |
| 25 | 29·453 | 33·3 | 4·7 | ·136 | 62 | | W. | 27·727 | 27·3 | 5·3 | ·116 | 53 | | W. | 29·077 | 31·7 | | N W. | 26·3 | 7·0 | | W. |
| ○ 26 | 29·541 | 25·3 | 8·0 | ·100 | 66 | 0·500 | E. | 27·721 | 24·0 | 4·0 | ·104 | 69 | 0·224 | E. | 29·147 | 21·7 | 10·0 | S W. | 20·0 | 6·3 | 0·050 | E. |
| 27 | 29·402 | 17·3 | 10·7 | ·108 | 59 | | N E. | 27·634 | 29 3 | 7·3 | ·144 | 63 | | W. | 29·010 | 22·0 | 1·7 | (var.) | 20 0 | 8·7 | | W. |
| 28 | 29 345 | 23·7 | 6·3 | ·085 | 43 | | E. | 27 668 | 24·3 | 5·0 | ·134 | 77 | 0·045 | (var.) | 29·000 | 24·0 | 6·0 | N W. | 19·7 | 14·3 | | N W. |
| 29 | 29·128 | 35·0 | 11·3 | ·123 | 54 | | (var.) | 27·472 | 40·7 | 16·3 | ·185 | 58 | | W. | 28·757 | 35·0 | 11·0 | S W. | 30·0 | 11·7 | | W. |
| 30 | 29·340 | 23·3 | 11·7 | ·061 | 41 | | W. | 27·655 | 16·0 | 24·7 | ·096 | 85 | | W. | 28·953 | 20·3 | 11·3 | N W. | 16·0 | 14·0 | 0·100 | N W. |
| 31 | 29·423 | 19·0 | 5·0 | ·066 | 43 | | (var.) | 27·663 | 17·3 | 7·3 | ·140 | 88 | | W. | 29·040 | 22·0 | 1·7 | N W. | 16·7 | 4·7 | | N W. |
| Means | 29·376 | 29·8 | 7·7 | ·120 | 60 | 3·286 | N 54° W | 27·657 | 28·3 | 9·0 | ·149 | 72 | 2·797 | S 65° W | 29·037 | 26·5 | 8·0 | N 66° W | 24·4 | 9·2 | 2·905 | N 65° W |

*Abstract of Meteorological Observations for January, 1861; made in Erie, Northumberland, Adams, and Dauphin Counties, Pennsylvania, for the Committee on Meteorology of the Franklin Institute.*

**Erie, Erie Co.—Lat. 42° 8′ N. Long. 80° 12′ W. Height about 640 feet. Benjamin Grant, Obs.**

| 1861. Jan. | Barom. Mean | Thermom. Mean. | Thermom. Mean daily range. | Force of Vapor. 2 P. M. | Relative humidity. 2 P. M. | Prevail'g winds. |
|---|---|---|---|---|---|---|
| | Inch. | ° | ° | Inch. | Per ct. | Direc. |
| 1 | 29·527 | 32·0 | 10·0 | ·107 | 53 | S W. |
| 2 | 29·374 | 37·0 | 5·7 | ·102 | 40 | S W. |
| ☾ 3 | 29·256 | 29·3 | 7·7 | ·123 | 77 | (var.) |
| 4 | 29·395 | 30·0 | 3·3 | ·129 | 78 | N. |
| 5 | 29·571 | 26·0 | 3·3 | ·087 | 55 | S W. |
| 6 | 29·405 | 33·3 | 7·3 | ·148 | 70 | S. |
| 7 | 29·099 | 42·7 | 14·0 | ·259 | 77 | S W. |
| 8 | 29·354 | 33·7 | 9·7 | ·138 | 70 | N W. |
| 9 | | | | | | |
| ● 10 | | | | | | |
| 11 | | | | | | |
| 12 | 29·434 | 15·7 | | ·055 | 53 | E. |
| 13 | 29·689 | 9·7 | 7·3 | ·063 | 56 | S. |
| 14 | 29·367 | 30·3 | 20·7 | ·143 | 79 | S. |
| 15 | 29·151 | 35·3 | 5·0 | ·177 | 80 | S. |
| 16 | 28·810 | 42·7 | 7·3 | ·226 | 76 | (var.) |
| 17 | 29·336 | 34·7 | 8·0 | ·175 | 89 | W. |
| ☽ 18 | 29·123 | 39·7 | 5·0 | ·158 | 64 | S. |
| 19 | 29·132 | 34·0 | 5·7 | ·154 | 79 | W. |
| 20 | 29·349 | 28·7 | 5·3 | ·118 | 68 | N W. |
| 21 | 29·592 | 27·7 | 1·0 | ·111 | 67 | N. |
| 22 | 29·865 | 19·7 | 8·0 | ·117 | 76 | N E. |
| 23 | 29·735 | 31·0 | 11·3 | ·090 | 40 | S E. |
| 24 | | | | | | |
| 25 | | | | ·081 | 47 | (var.) |
| ○ 26 | 29·457 | 24·3 | | ·117 | 76 | S W. |
| 27 | 29·256 | 27·3 | 3·0 | ·099 | 57 | S. |
| 28 | 29·325 | 28·3 | 1·0 | ·143 | 79 | W. |
| 29 | 29·053 | 35·0 | 6·7 | ·150 | 63 | W. |
| 30 | 29·415 | 17·3 | 17·7 | ·078 | 83 | W. |
| 31 | 29·403 | 21·0 | 3·7 | ·071 | 50 | W. |
| Means | 29·356 | 29·5 | 7·4 | ·127 | 67 | S 42° W |

**Shamokin, Northumberland Co.—Lat. 40° 45′ N. Long. 76° 30′ W. Height, 700 ft. P. Friel, Observer.**

| 1861. Jan. | Barom. Mean. | Thermom. Mean. | Thermom. Mean daily range. | Force of Vapor. 2 P. M. | Relative humidity. 2 P. M. | Rain and snow. | Prevail'g winds. |
|---|---|---|---|---|---|---|---|
| | Inch. | ° | ° | Inch. | Per ct. | Inch. | Direc. |
| 1 | 29·480 | 20·7 | 2·7 | ·120 | 61 | | W. |
| 2 | 29·314 | 26·3 | 5·7 | ·051 | 19 | | E. |
| ☾ 3 | 29·004 | 34·8 | 11·8 | ·136 | 62 | 0·400 | E. |
| 4 | 29·178 | 27·3 | 7·5 | ·148 | 89 | 0·050 | E. |
| 5 | 29·468 | 26·2 | 3·2 | ·131 | 70 | | W. |
| 6 | 29·379 | 31·0 | 11·2 | ·051 | 19 | | (var.) |
| 7 | 28·983 | 40·2 | 9·2 | ·254 | 92 | 0·300 | W. |
| 8 | 29·161 | 35·8 | 5·0 | ·183 | 90 | | W. |
| 9 | 29·038 | 33·3 | 2·5 | ·156 | 79 | 0·105 | E. |
| ● 10 | 28·812 | 29·7 | 3·7 | ·155 | 79 | | W. |
| 11 | 29·179 | 15·0 | 14·7 | ·098 | 100 | 0·410 | W. |
| 12 | 29·161 | 15·0 | 11·3 | ·106 | 86 | 0·190 | W. |
| 13 | 29·622 | −12·7 | 27·7 | ·011 | 29 | | W. |
| 14 | 29·455 | 19·7 | 32·3 | ·106 | 86 | 0·195 | W. |
| 15 | 29·099 | 32·3 | 9·3 | ·116 | 53 | 0·715 | (var.) |
| 16 | 28·798 | 37·3 | 5·0 | ·195 | 82 | | E. |
| 17 | 29·211 | 38·3 | 1·7 | ·228 | 87 | | N W. |
| ☽ 18 | 29·209 | 30·5 | 7·8 | ·168 | 89 | 0·100 | (var.) |
| 19 | 29·091 | 38·0 | 7·5 | ·177 | 66 | | W. |
| 20 | 29·129 | 30·5 | 7·2 | ·168 | 95 | | W. |
| 21 | 29·350 | 22·8 | 8·7 | ·143 | 79 | | N W. |
| 22 | 29·650 | 21·0 | 7·5 | ·117 | 87 | | W. |
| 23 | 29·781 | 17·3 | 6·3 | ·094 | 73 | | E. |
| 24 | 29·246 | 32·3 | 15·0 | ·162 | 89 | 0·300 | (var.) |
| 25 | 29·249 | 31·7 | 4·0 | ·168 | 89 | | E. |
| ○ 26 | 29·314 | 24·3 | 7·3 | ·117 | 76 | 0·200 | W. |
| 27 | 29·228 | 17·3 | 10·3 | ·148 | 89 | | W. |
| 28 | 29·198 | 28·0 | 10·7 | ·150 | 80 | | W. |
| 29 | 29·005 | 32·5 | 4·5 | ·129 | 61 | | E. |
| 30 | 29·149 | 22·8 | 9·7 | ·105 | 80 | | (var.) |
| 31 | 29·296 | 19·5 | 3·3 | ·100 | 79 | | W. |
| Means | 29·233 | 26·4 | 8·8 | ·138 | 74 | 2·965 | N 76° W |

**Gettysburg, Adams Co. Lat. 39° 49′ N. Long. 77° 18′ W. Ht. 624 ft. Prof. M. Jacobs, Obs.**

| 1861. Jan. | Barom. Mean. | Thermom. Mean. | Thermom. Mean daily range. | Rain and snow. | Prevail'g winds. |
|---|---|---|---|---|---|
| | Inch. | ° | ° | Inch. | Direc. |
| 1 | 29·789 | 10·8 | 11·0 | | S W. |
| 2 | 29·555 | 30·0 | 9·2 | | N. |
| ☾ 3 | 29·278 | 34·0 | 14·0 | 0·850 (2–4) | N. |
| 4 | 29·529 | 30·0 | 4·0 | | N W. |
| 5 | 29·758 | 27·7 | 2·3 | | (var.) |
| 6 | 29·668 | 26·3 | 7·3 | 0·185 (6–7) | S. |
| 7 | 29·284 | 37·0 | 10·7 | | S S W. |
| 8 | 29·436 | 36·7 | 1·7 | | W N W |
| 9 | 29·304 | 33·7 | 3·0 | 0·250 | (var.) |
| ● 10 | 29·196 | 29·0 | 4·7 | | N W. |
| 11 | 29·493 | 18·0 | 11·0 | 0·080 | (var.) |
| 12 | 29·518 | 18·1 | 9·0 | | (var.) |
| 13 | 29·995 | 3·9 | 14·4 | | S. |
| 14 | 29·693 | 16·0 | 12·4 | 0·365 | N E. |
| 15 | 29·380 | 30·0 | 13·7 | 0·870 (15–16) | N. |
| 16 | 29·106 | 37·3 | 7·3 | | N W. |
| 17 | 29·513 | 34·7 | 4·7 | | N W. |
| ☽ 18 | 29·433 | 34·3 | 3·7 | 0·180 | S S W. |
| 19 | 29·249 | 35·7 | 4·7 | | N W. |
| 20 | 29·455 | 30·7 | 5·0 | | N W. |
| 21 | 29·644 | 26·0 | 4·7 | | N W. |
| 22 | 29·986 | 24·0 | 6·0 | | N. |
| 23 | 30·046 | 22·0 | 2·0 | | N N E. |
| 24 | 29·523 | 29·7 | 7·7 | 1·178 | (var.) |
| 25 | 29·451 | 31·7 | 4·0 | | W. |
| ○ 26 | 29·592 | 24·3 | 7·3 | 0·400 | N N E. |
| 27 | 29·513 | 13·7 | 12·3 | | (var.) |
| 28 | 29·543 | 20·3 | 8·3 | | W N W |
| 29 | 29·315 | 31·7 | 7·7 | | S S W. |
| 30 | 29·470 | 22·7 | 10·3 | | N W. |
| 31 | 29·576 | 15·7 | 8·3 | | S. |
| Means | 29·528 | 26·0 | 7·5 | 4·358 | N 48° W |

**Harrisburg, Dauphin Co. 40° 16′, N. 76° 50′ W. Ht. 300 ft. John Heisely, M.D., Obs.**

| 1861. Jan. | Barom. Mean. | Thermom. Mean | Thermom. Mean daily range. | Rain and snow. | Prevail'g winds. |
|---|---|---|---|---|---|
| | Inch. | ° | ° | Inch. | Direc. |
| 1 | 30·097 | 21·0 | 6·7 | | (var.) |
| 2 | 29·873 | 24·0 | 3·0 | 0·750 (2–3) | S W. |
| ☾ 3 | 29·561 | 36·0 | 12·0 | | N. |
| 4 | 29·790 | 33·0 | 3·0 | | N W. |
| 5 | 30·047 | 31·3 | 1·7 | | W. |
| 6 | 29·986 | 32·3 | 4·3 | | S. |
| 7 | | | | | E. |
| 8 | 29·783 | 39·3 | | | (var.) |
| 9 | 29·605 | 35·7 | 3·7 | 0·368 | (var.) |
| ● 10 | 29·451 | 32·0 | 5·0 | | (var.) |
| 11 | 29·713 | 21·7 | 10·3 | 0·200 | E. |
| 12 | 29·746 | 21·7 | 4·0 | | (var.) |
| 13 | 30·288 | 7·7 | 14·0 | | (var.) |
| 14 | 30·042 | 17·7 | 9·7 | 0·287 | N E. |
| 15 | 29·675 | 32·7 | 15·3 | 0·700 (15–16) | (var.) |
| 16 | 29·375 | 37·3 | 4·7 | | E. |
| 17 | 29·771 | 39·3 | 2·7 | | W. |
| ☽ 18 | 29·733 | 34·0 | 5·3 | 0·168 | (var.) |
| 19 | 29·540 | 38·3 | 4·3 | | W. |
| 20 | 29·721 | 35·0 | 4·0 | | N W. |
| 21 | 29·945 | 31·0 | 4·0 | | N W. |
| 22 | 30·307 | 26·3 | 4·7 | | N. |
| 23 | 30·365 | 24·7 | 1·7 | | N E. |
| 24 | 29·816 | 31·7 | 7·0 | 0·866 | N E. |
| 25 | 29·851 | 34·7 | 4·3 | | (var.) |
| ○ 26 | 29·886 | 28·0 | 6·7 | 0·331 | W. |
| 27 | 29·803 | 23·7 | 7·7 | | W. |
| 28 | 29·803 | 29·3 | 5·7 | | W. |
| 29 | 29·585 | 31·7 | 3·7 | | W. |
| 30 | 29·755 | 24·3 | 7·3 | | N W. |
| 31 | 29·865 | 22·7 | 1·7 | | W. |
| Means | 29·824 | 29·3 | 5·8 | 3·670 | N 41¼° W |

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MAY, 1861.

## CIVIL ENGINEERING.

Translated for the Journal of the Franklin Institute.

*Examination of some Questions relative to Transportation.* By M. LAMARLE, Chief Engineer "des Ponts et Chaussées." Translated by J. BENNETT.

(Continued from page 224.)

IT is natural, where no appreciable economy can be found in expense of transportation, that we should reject all difference in tariffs.

9. We have now to examine what is upon this point, the special right, created by the conditions of contract accepted by the companies. These acts, drawn up in 1844 and 1845, have been revised in later years, and the article relative to the reductions of tariff, has received in 1857 a great change.

The ancient conditions had the following clause in relation to private bargains:

"In case the Company shall accord to one or more forwarders, a reduction upon any of the prices of the tariff, before putting in execution, it must inform the administration, and the latter shall have the right to declare the reduction once agreed upon, as binding upon all forwarders."

The new article reads as follows:

"When the company shall judge proper, whether for the whole distance, or for a partial distance of the railroad, to reduce with or without conditions below the limit determined by the tariff, the taxes it is authorized to collect, the reduced taxes shall not be raised till after a

delay of three months at least for passengers, and one year for merchandise.

"Every modification of tariff proposed by the companies shall be announced a month beforehand by postings; the collection of the modified tariffs shall not be made, except with the confirmation of the upper administration, conformably to the dispositions of the ordonnance of 15th Nov., 1846.

"The collection of taxes must be made without distinction and without favor. Every private compact which has for effect the granting to one or more forwarders a reduction upon the approved tariffs, is *formally forbid:* this disposition, however, is not applicable to compacts made between the government and companies for the interest of public service, nor to reductions which shall be granted by the companies to indigents.

"In case of lowering the tariff, the reduction shall be made proportionally upon the toll and upon transportation."

We see from these citations that the public administration has, since 1845, recognised the danger of private compacts, since it has decided to pronounce their formal interdiction. As to reductions of tariffs, with or without conditions, they must in all cases be publicly announced a month in advance, to be confirmed by the government, and applied without distinction or favor. The liberty of companies, is thus subjected to numerous restrictions; they can only proceed but with general measures, and their proposals before being applied, must be submitted to the double proof of public observation, and the inspection of the government, free to confirm or reject them.

Such is the special right created by the contracts, with a wise and legitimate foresight. Never was the protecting intervention of public authority more necessary or better justified. We have seen in the example already cited, that the Northern Company authorized to collect 27·90 fr. upon oil from Quiévrain to Paris has reduced its tariff to 10·50 fr.; it could still, without loss, go below this figure; but is it not an enormous power, this faculty of increasing at will by 17·40 fr. the price of a ton of oil, which is hardly worth 14 fr. at the mine? If the company, supposed to act free without control upon its tariffs, see fit to specially favor the Belgian mines, might it not grant them an immediate premium, far superior to the customs upon oil, 1·50 fr., and so render completely illusory the protection of the national work, which should be guaranteed? Would it not depend upon it also to artificially render the conditions of industrial production, better at Paris and its suburbs, than at the intermediate places, Amiens for example, thus upsetting all geographical relations, and destroying the best established positions? It would suffice to maintain for these localities, the maximum tax of tariff, 13·20 fr., and to grant to Paris and its suburbs the reduction of taxes to 10·50 fr. Is there not reason to fear the possible consequences of such a power exerted upon oil, an essential element in all fabrications? The exercise of this power would not be confined to this commodity: the great latitude resulting from the tariff for the last class, increases for the superior classes of merchandise,

because the taxes rise much more rapidly than the expenses of traction. Without exaggeration, it may be said, no association ever had at its disposal a more powerful agent upon the industry and commerce of the country. From this results the stern necessity, consecrated by the conditions of their charter, of an elevated control to preside over the reductions of tariffs, whose consequences may be so favorable or disastrous, as they are inspired with a regard for the general interest, or with the too common and egotistic suggestions of private interest.

The public administration being invested with the right of confirming the proposed reductions of companies, may undoubtedly reduce the *differential element* of tariffs to the limit which we have indicated as a *maximum*, to wit: the amount of economies in the cost of traction, from the accepted conditions, relatively to the length, the mass, and the distribution of transportation. It can and should in our opinion, reject in so far as *exceptional*, or render *general* every reduction above this figure.

It may possibly be objected, that thus operated, the reductions may not bear proportionally upon the tolls and transportation. This would not be exact; for nothing forbids a distribution of the total amount of reduction determined in each case, proportionally to the figures of the two taxes. This estimation at a relative value is not at present effected in the modified tariffs, and the reason is easily found. It has in fact a practical and possible application only in rare cases, where a company uses its carriages upon a route of which it is not the grantee. Whatever may be the force of such an objection so easily raised against our proposal, the distribution in question should never for an instant be opposed to the principle which governs this discussion, the rigorous obligation to maintain and hold safe, the fundamental base of our legislation, the equality of all as to taxation.

10. Railroad Companies cannot be compared with private enterprises. Most generally they act in virtue of a delegation of the public authority. Most of them have received from the state either considerable subsidies, or guaranties of interest; the only regard in which they may be compared with private industry, is in the execution of the transportation, and it is by reason of the monopoly which they enjoy for this operation that the intervention and control of the government has become indispensable.

To place, as has been sometimes done, a regulating check upon this monopoly, in the maximum limits of tariffs determined by acts of concession, is to fall into a complete illusion. These maxima are applied only to passengers and costly merchandise, and not to those commodities which are the object of the struggle with navigable routes. It would be absolutely impossible for railroads, whatever the distance of the competing line, to raise their tariffs to the maximum level of their conditions of charter; to raise the price of carrying oil between Quiévrain and Paris from 10·5 fr. to 27·9 would create an industrial revolution, and aside of the fear of inevitable evils the well-understood interest of the company would not permit it.

We will not attempt to determine, for the different cases which

may be presented, a rate of tariff suited to the maximum of net products. To do this would require us to assign exactly the law of the variations of traffic corresponding with those of the taxes; yet we will cite an example within our personal experience, which may enable us to appreciate the profits to be derived from certain raising of the tariffs.

Upon the route from Mons to Lille, the freight before the execution of the works of improvement of the lower Scarpe, stood at the rate of 8·5 fr. per ton; the total mean movement in the last years, was 260,000 tons; after the improvements upon this river, the freight fell to 4·06 fr., and the mean circulation (1839 to 1842) reached 448,000 tons. The distance from Mons to Lille being 100 kilometres (62 miles) by railroad, these two prices correspond to 0·085 fr. and 0·04 fr. per kilometre, (2·54 cts. and 1·19 cts. per mile.)

At the price of 0·04 fr., a railroad company, which should expend nearly 0·02 fr. per ton per kilometre (0·598 cts. per mile) upon such a distance, would obtain a net product of 0·02 fr. per unit, or for 448,000 tons 8960 francs.

On the other hand, at the price of 0·085 fr. the profit would be 0·065 fr. per ton per kilometre, its total, notwithstanding the corresponding reduction of traffic to 260,000 tons, would have attained a figure nearly double, or 16,900 francs.

In a similar case, there would then be a considerable advantage in raising the tariff from 0·04 fr., a figure nearly equal to the rate of the actual reductions up to 0·085 fr., a rate inferior to that of the chartered schedule of prices, even though the circulation be notably reduced by the increased cost of transportation.

The raising of the tariffs, so advantageous between certain limits to companies, is not operated suddenly: the necessary circumspection always imposed by great industrial interests, the ignorance of the precise law of the variations of traffic, the fear by too sudden a rise of reviving discouraging rivalries, all combine to urge upon companies a progressive empirical march, and an approach, by trials, to the figures which shall yield a net maximum product.

We have seen that the common roads cannot compete with railroads: when the considerable material of which the canal disposes, shall by losses, fall below the needs of circulation, commerce will not be tempted to construct costly vehicles whose ruin lays at the mercy of ulterior abatements of tariffs.

Thus the gradual increase of tolls, operated with a wise moderation, will without any risk, increase the profits of companies; they will advance necessarily towards this end, aided by the increase of freight, which will be realized at the expense of commerce upon navigable lines, as soon as their material shall have become insufficient.

A sudden increase in the cost of transportation would certainly lead to industrial and commercial catastrophes: a progressive increase would favor the transition, but would produce definite effects of the same order in making fabrications more costly, and thus checking the indus-

trial range. In being tardily brought to pass, the pressure would be none the less real, none the less fatal.

11. The maximum of chartered rates, cannot then, as we have seen, constitute a guarantee against monopoly for the transportation of heavy masses, since the interest of companies determines their holding below them. This well-understood interest will not constitute a real guarantee against an ulterior raising of the taxes, temporarily reduced in the presence of competition; and in reality there exists against the dangers which threaten the industrial interest, but one moderating efficacious action, that of the competition of navigable routes. To their existence we owe the reductions of price accorded by the companies, for many years past, and which at first were regarded as utopian: have we not heard a commission of the Belgian chambers declare in 1843, that the State railroad could not transport without loss, under 0·07 fr. per ton per kilometre, and do we not daily see the French companies working with profit at the rate of 0·03 fr. to 0·04 fr. (0·897 cts. to 1·19 cts. per mile)?

These so precious advantages for industry, which the competition of canals alone has procured, and which it alone can assure for the future, shows how great a public interest belongs to the maintenance of this fruitful rivalry. Thus the state cannot, without compromising the industry of the country, without a veritable suicide, allow the introduction in the differential tariffs of companies of favoring prices, of true premiums, for the encouragement of an interdict upon the rivers and canals, the great part of which it owns and works. The exclusive clause (clause d'abonnement), the last arm of an unbridled competition against the navigable routes, the sole effectual guarantee against the dangers of monopoly, should be strenuously repelled.

12. The suppression of these exclusive tariffs, the radical modifications which we have proposed for the differential taxes, will undoubtedly render less unequal the conditions of the strife, and will be a point gained. But still it will exist, and restrained even within these limits, the power of the railway will yet be very threatening for the future of navigable routes.

In the first year following the opening of the northern railroad, the public administration felt the necessity of improving the competing navigable routes. In the basins of the Aa and Escaut, the bases of collection were regulated, the price of tolls was reduced, and numerous improvements were perseveringly adopted in the condition of the working stock, and in the working of the lines; thanks to these tutelary measures, the boating interests were maintained, and, up to the present, its general traffic has continued to increase. Still, we have seen how much more rapid has been the progress of the railroad, and how it draws the merchandise which seemed to belong exclusively to the canals. The extension of traffic and the progressive development in the working stock of railroads, render the danger as great now as it was in 1849. As then, it has become necessary to counsel and act for the support of the navigable routes, which alone can assure the country a constant moderation of taxes upon railroads.

Well convinced of the vitality of navigation, this admirable instrument of economical transportation, we firmly believe in its ultimate powers of resistance, and we will endeavor to indicate here, with the reasons of our hope, the measures necessary to realize it.

13. The tolls with which rivers and canals are burthened, although not high in their mean rate, yet far surpass, upon some lines where there is a great competition, the amount of the expenses of maintenance. It is thus that, between Belgium and Paris, the total of navigation duties, notwithstanding the reductions already assented to, amounts to . . . 6,000,000 fr.
While the cost of maintenance of the lines to which they apply, scarcely reaches . . 800,000 "

Leaving for net products or impost, . 5,200,000 fr.

The mean net product of tolls upon all the canals directed by the state, exceeds 2800 francs per kilometre ($837 per mile), and so far exceeds the cost of maintenance. Upon the conceded routes, the difference is still greater.

If then it can be said that, upon certain lines the tolls represent at most the expense of maintenance, the assertion does not apply to the general network, and especially to the most frequented routes. There remains, then, to be made, a great reduction upon the rate of tolls, and we add that, for some of the routes, this diminution, eminently useful to the general interests, would at the same time be an act of rigorous justice.

When the state makes a new canal, it should undoubtedly seek to receive from its tolls, independently of the sums necessary for maintenance, the interest of capital devoted to its establishment. This interest, which the public treasure should obtain, under penalty of favoring, at the expense of all, the neighboring localities of the new canal, comes into its possession in different ways; first, the tolls, then the ulterior increase of direct and indirect taxes, resulting from the industrial and commercial developments produced by the circulation of the new route.

Often it happens, that the impost of tolls furnishes alone the maintenance of the way, and the interest and redemption of the capital; this is the case in the concessions. At other times, the canals are made by the localities, or paid for by them; sometimes it is a matter of expired concessions, which have effected a reimbursement of capital, or of lines executed by the state having a long time since repaid its advances, by the excess of receipts above expenses.

In the last three cases, every toll above the cost of maintenance becomes a veritable tax, unjust, because it strikes upon an instrument of production, upon a utensil; fatal, because it tends to restrict the route, and to replace the natural difficulties which it has overcome, by an artificial obstacle of tariffs. The evil resulting from their too great elevation is general: it reacts upon the commerce and industry which feed the canal; the treasury itself is often affected by the pressure

exerted by the tariffs upon the different sources of public revenue. When, on the contrary, the state or the companies lower the tariffs, the loss they experience is always inferior to the amount of the reduction, because there follows naturally from it a development of traffic, which is transferred into an increase of revenue of every kind, even of tolls. The Sambre and the canal joining the Sambre with the Oise, present a striking example of this fact; by a reduction of 25 per cent. operated upon the tariffs in 1841, the returns rose the year following from 239,048 to 449,248 francs; it has not ceased to increase up till 1849, when a new reduction, nearly similar in rate, brought the revenue from 1,200,258 to 1,406,860 francs. Thus each of these abatements of tariffs have been followed by a considerable increase of receipts, and they have not ceased to rise even till the opening of the rival railway; they had attained in 1856, a total of 2,060,273 francs, which gives, in sixteen years, an increase of eight-fold (1,829,225 francs upon 239,048 francs). We have also seen reductions made in 1849 upon the whole of the northern rivers and canals, produce, in less than five years, a total increase of 1,783,566 francs in the yield of tolls, and carried from 5,594,499 to 7,378,065 francs.

In this particular case, the advantage reaped by commerce is far superior to the reduction made upon the fees of navigation; the latter guaranties the permanence of those already granted upon competing routes; thus its effect is double, and reacts effectively upon the circulation, which the navigable routes do not traverse.

We cannot here indicate all the reductions to be made, and limit ourselves to pointing out a serions inequality which bears upon the lines of the basins of the Aa, of Escaut, and the Saint Quentin canal. Oil, placed by all the other schedules of tariffs in the last rank of taxable commodities, is here held in the first class, and pays the highest tax. It is the last vestige of the exceptional regime which these routes have so long suffered; it would be well to annul it, especially when the newly discovered oil mines of Pas-de-Calais, and the constantly increasing consumption of this combustible yield to the economy of its transportation a greater value than ever.

The facts above given, show how great is the public interest in reducing the tolls. Before leaving this subject, as a measure of the extent of advantages to be realized in this way, we would suggest that upon a single line (from Belgium to Paris), a diminution of 87 per cent. (5,200,000 upon 6,000,000 francs) might be made without changing the resources necessary for the maintenance of the various canals and rivers of which it is composed.

14. The material improvements of which navigable routes are susceptible, constitute a second class in a progress of unquestioned value. If now it is difficult to devise the establishment of any new extended canal, if, in most cases, a profound study of this kind of question leads to a negative solution,* it is otherwise, in the matter of the improvement of existing routes already traversed by a great circulation.

* The latest proposed canals have cost at a mean 240.000 francs the kilometre ($71.760 the mile); at this rate, there would be needed for interest, maintenance, and reimbursement, at least 14,000 francs per kilometre ($4186 per mile). Now, in presence of railroads, the tolls cannot exceed 0·02 franc per ton (0·598 ct.) We should then count upon a traffic of 700,000 tons, which few lines attain, even after many years.

All expenses are thus productive, and some beyond all previous hope.

Some examples, selected from many northern lines, give evidence of the great gain attendant upon such works.

The author here gives a table in which the cost of improvements upon the

| | |
|---|---|
| Escaut and St. Quentin canal are set at . | 6,000,000 fr. |
| Those upon the lower Scarpe and Deule at . | 2,650,000 " |
| Total, | 8,650,000 " |

It appears that the total annual gain of 1847 over the year 1833, or that resulting from the execution of the works, rose to 8,939,768 fr., and thus exceeded the amount of capital expended, the interest being over 100 per cent.

All the useful expenditures for the improvement of canals will not of course be so productive. But we may affirm with certainty that upon the great arteries whose circulation varies from 300 to 1200 thousand tons, all the works which may facilitate the passage of boats, will return with usury to the public the sacrifices made for their execution.

Results of high importance may often be obtained in operating upon lines with small traffic. Thus in the improvement of the upper Lys and the Lawe rivers, but little frequented, its influence was felt at the same time upon the competing canal from Aire to the Bassée, and so there will be a positive reduction in the cost of transportation of heavy masses, now exceeding 400,000 tons, which will undoubtedly be increased, from the workings of the oil mines recently discovered in Pas-de-Calais.

The Northern navigation has for forty years been the object of numerous works, and still we may without undervaluing the improvements effected affirm, that there remains yet much to be done. Now if this is true for this part of France, where the navigable lines have reached a great relative perfection, why should we not expect elsewhere, useful conquests to be made, and important economies to be realized?

We should place in the first rank, the improvement of rivers which unite or prolong the canals; with these relatively little costly works we may increase the value of extended lines, which in good condition upon the greater part of their development, are often paralyzed by defect of anchorage and different obstacles upon the rivers from which they derive their flow. Other improvements may undoubtedly be proposed; but their research is foreign to our purpose: we only desire to show what advances can be made in this direction. The studies which the government have prescribed to determine the expenses called for in the improvement of navigable routes bear witness of its deep solicitude for them, and of its confidence in their success.

15. It remains to examine the special conditions of the working of navigable routes, and to search out the economies of which they are susceptible.

The expenses of transportation comprise:

1st. The general expenses independent of the distance.

2d. The special expenses applicable to the line.

The general expenses may be valued as a mean at 1 fr. per ton for oil (including the customs), and are distributed as follows:

| | |
|---|---|
| Insurance, | 0·100 fr. |
| Freight commissions, | 0·075 " |
| Charge paid by boatman, | 0·090 " |
| Customs, | 0·035 " |
| 20 days wharfage, | 0·700 " |
| | 1·000 fr. |

An increase in the draft of boats, a better organization of *stoppages*, and the hastening the discharge, concur to reduce the expenses. The first measure will admit of an increase from 200 to 270 tons per boat; the second will yield 330 days of navigation yearly, instead of 275; the third will reduce the time of stopping from 20 to 15 days.

Thus the part of the general expense, answering to the days of stoppage, 0.70 fr., may be progressively reduced to

$$0{\cdot}70\ \frac{275 \times 200 \times 15}{330 \times 270 \times 20} = 0{\cdot}32 \text{ fr.}$$

Which gives an economy of 0·38 fr. and reduces the cost of general expense applicable to these transportations to 0·62 fr.

When we compare the necessary forces to draw the same useful load upon canals and railroads, in their ordinary working condition, we find a great difference in favor of navigable routes.

Thus for hauling a boat 5 m. (16·4 ft.) wide, drawing 1·3 m. (4·26 ft.) of water, and carrying 225 tons of useful load with a velocity of 2 kilometres (1·24 miles) per hour (1·8 ft. per second) upon a canal with 18 square metres ($193\frac{3}{4}$ sq. ft.) of section, there is required an effort of 72·05 kil. (159 lbs.)*

Upon a railroad, the gross weight corresponding to the same load of 225 tons will be 375 tons (locomotive and tender included), and the corresponding effort at the rate of 4 kilogrammes (8·82 lbs.) per ton will be 1500 kilogrammes (3308 lbs.)

Here undoubtedly lays the true power of the navigable route; but while appreciating its superiority in this respect, we must not exaggerate its importance, nor disregard the conditions. If we look for greater speed upon canals, the effort necessary for this increases proportionally to the square of the velocity,† and to attain the speed giv-

* The formula, given by D'Aubuisson des Voisins, in his Traite d'hydraulique:

$$E = 140 \text{ k. } \frac{s^2\, v^2}{c + 25} \text{ gives in this case } E = 140 \text{ k. } \frac{(7{\cdot}50 \times 0{\cdot}55)^2}{18 + 15}$$

The same equations in units of feet and lbs. is

$$E = 2{\cdot}664\ \frac{s^2\, v^2}{c + 2s}$$

See page 297 Bennett's translation.

† We leave out of the question fast boats, necessarily very light, for which the resistance follows another law.

en to the transportation of bulky merchandise upon railroads (20 kilometres or 12·42 miles per hour) requires an effort one hundred times greater than the above calculated, or 7205 kilogrammes, and as upon the railroad the effort for this velocity is but 1500 kilogrammes, the proportion between the two routes is completely reversed. The great economy of transportation by the canal supposes implicitly a moderate speed; but in diminishing the velocity to reduce the expense of haulage, we increase the expenses in boating, material, and equipage, which are used a greater length of time; it follows that there must exist in each particular case, a velocity corresponding with the minimum net cost.

(To be Continued.)

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*On the Results of Trials of Varieties of Iron Permanent Way.* By Mr. F. Fox, M. Inst. C. E.

From Newton's London Journal, March, 1861.

The author stated, that he did not wish to be thought an advocate for the superiority of either of the systems tried over other plans, or of iron over timber for permanent way, under any and all circumstances; his object being merely to record results of actual trials, and the conclusions to which they led.

In 1853, an experimental length of a quarter of a mile (double line) of iron way, on the principle of Mr. I. J. Macdonnell (M. Inst. C. E.,) was laid on the Bristol and Exeter Railway. It consisted of a continuous rolled iron rail bearer, weighing, on an average, 83½ lbs. per lineal yard, and 11 inches in width. The bearers were united by joint or saddle plates 30 inches in length, weighing 50½ lbs. each. The bearers had a rise in the centre of $\frac{9}{16}$ths of an inch, and a rib or tongue was rolled on the upper side, which fitted approximately into the hollow of the bridge rail. The rails originally laid weighed only 53¾ lbs. per yard. Between the rail and the bearer, a thin packing of pine wood was placed, the grain being in the direction of the length of the rail. The rails, the bearers, and the joint plates, were bolted together, the distances between the intermediate bolts being so arranged as to admit of a rail being readily turned by unscrewing the nuts, or of a new rail being put in, without "opening out" the ballast. Transoms, or cross ties of angle iron were placed at average intervals of 12 feet between the two rails, and 24 feet between the two lines. This system differed from the Barlow way, in having the rail or wearing surface separate and easily removable from the bearing surface; but, on the other hand, it considerably exceeded the Barlow rail in weight. After a wear of more than seven years, this length of iron way was in good condition, and bid fair to continue so for some time to come. About one-third of the rails proved defective within the first two years and had been replaced by rails weighing 60 lbs. to the yard. The ballast, which was very indifferent, being a loamy gravel, had been well drained, and thicker packing, laid with the grain transversely to the direction

of the rail, had been introduced. The bearers and joint plates, transoms, and rails, were supplied at £7 per ton delivered, and the cost per single mile of this arrangement, exclusive of the cost of matching and laying, was £1936. The cost of a single mile of the longitudinal timber way, at the same period, taking the rails at the same weight and price, was estimated at £1850. It should be mentioned that iron was then low in price, whilst timber was high. Owing to the undue lightness of the rail, both of these calculations were below the cost of a well constructed permanent way.

As this experiment appeared on the whole to have been successful, it was determined to extend the trial, by laying one mile of double line, on this system, at a further distance from a station, so that all trains should pass over it at full speed. Some modifications were, however, made. The width of the bearer was increased to 12 inches, and its thickness was reduced to $\frac{9}{16}$ths of an inch, so that its weight was 75 lbs. per lineal yard. At the same time the curvature was slightly increased. The pine packing (creosoted) was thicker, and at the rail joints pieces of hard wood, laid with grain lengthwise; were substituted. The rails weighed 68 lbs. per yard. The contract for the bearers, joint plates, and transoms was taken at £9 10*s.* per ton, —the cost of rails being £9 8*s.* 8*d.* per ton. This length was laid in July, 1857, where the line had not long before been re-ballasted with hard clinker ballast. The cost of a single mile, exclusive of laying, amounted to £2511. One mile of timber way, laid with the same section of rail at the same time, cost about £2254.

As these trials appeared to give a reasonable expectation of the greater durability and diminished cost of maintenance of the iron way, the author felt justified in recommending a further trial, on a more extended scale, and on different districts of the railway. As the rolling and straightening of the curved section of bearer was alleged to be difficult, it was decided to adopt a flat section. The bearing surface was increased to 13 inches, the centre rib was rolled ½ an inch deeper, and the weight was thus brought up to 84 lbs. per yard. Rail joint plates of a similar section to the bearer joint plates were bolted underneath the bearer at every rail joint. Although this addition had been found advantageous, the way was still weaker at the rail joints than at any other part. Additional intermediate bolts were used, so that the upper and lower sections of the way were held together as a girder. The contract for the bearers, joints, and transoms, was taken at £9 12*s.* per ton, and the rails, being £8 13*s.* 1*d.* per ton, the cost per single mile was £2571.

In order to test the comparative strength of the different sections of bearer, of rail and bearer combined as laid, and of the rail and bearer joints with and without joint plates, a series of experiments were made, the results of which were given in tabular form. The distance between the points of support was 5 feet. Of the three sections of bearer only, that of 1853 (the first) showed the least, and the flat section of 1859 the greatest, deflection, under a load of about 5 tons; but in each case the ultimate strength did not exceed 7 tons. Of the three

sections of iron way complete, that of 1853 was the weakest, and the curved section of 1857, with a rail weighing 68 lbs. per yard, rather the strongest. The ultimate strength was reached under loads varying from 19 to 21 tons. An experiment with the flat bearer showed, as was expected, the increased stiffness gained by placing the centre rib downwards, thus practically deepening the girder. The ultimate strength of the timber way was ascertained to be 28½ tons, or 50 per cent. higher than the iron way. It was, therefore, determined still further to increase the section of the iron bearer. In this case the width of the bearer was 12 inches, and it was stiffened by a web underneath, 3 inches deep and ¾ of an inch thick (a plan which was claimed by Mr. W. Bridges Adams). The weight was reduced to 76 lbs. per yard, and the contract for this section was taken at £9 per ton. To stiffen the rail joints (which had no plates underneath), and to secure the ends of the rails, an iron plate, having a tongue rolled on it, was used. This section of way has been laid too short a time to warrant any decided expression of opinion of it, as compared with the other sections; but as a length of between 4 and 5 single miles was under trial, it would soon be seen if it possessed any advantages. It was perceptibly stiffer to travel over, and the middle web gave it a firmer hold in the ballast than either of the other sections. The cost of a single mile was £2385. This section was the fourth modification of rolled iron bearer under trial, the entire length being 14¼ single miles.

The partial failure of the Macdonnell way on the Bridport railway was then referred to; and it was asserted that it arose from the rails and bearers being too weak, and from a disregard of those appliances which the character of the gradients, curves, ballast, and subsoil rendered more than ordinarily necessary.

In May, 1858, a trial length, of a single half mile, of the cast iron sleeper way of Mr. De Bergue, was laid in immediate continuation of the Macdonnell way, and on the same kind of clinker ballast. Whilst still preferring a continuous rolled iron to any cast iron way, the author felt bound to state that not a single sleeper had been broken, the nuts of the bolts did not work loose, the rails wore very well, and with the exception of a little depression at the fished rail joints, the line kept as good a "top" as could be desired, and was as easily maintained, but it was more rigid. The cost of this arrangement per single mile was £2103, or £300 per mile less than the Macdonnell way of the same period

The merits and defects of the continuous rolled iron permanent way were thus stated. The defects, or supposed defects, appeared to be:—1. The great cost, at present prices, almost precluding its adoption on a railway of limited capital. 2. The difficulty of getting the bearers rolled. 3. The possible increased wear of the rails. 4. The greater "wash" of all but very good ballast, inseparable from all iron ways, resting on or near the surface. And, 5. The difficulty of laying on sharp curves, and of keeping in place when laid. Its presumed merits were:—1. Greater economy in the long run, owing to increased dura-

bility. It was estimated that the cost of renewal of the longitudinal timber way was £45, and of the iron way only £21, per single mile per annum, or less than half, without reckoning the considerable item of labor in the replacement of the timbers. 2. Saving in maintenance, and facility for packing, owing to no "opening out" being required. 3. The safety of the iron way, especially as contrasted with a timber way which had been long laid. 4. The facility of exchanging worn rails. 5. The preservation of correct gauge. 6. The lowness of the crown of the rail above the bearing surface. 7. Saving in the depth of ballast in the case of a new line. And, 8. The equableness of the motion, rendering it probable that less injury would be sustained by the rolling stock.—*Proc. Inst. Civ. Eng.*

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## MECHANICS, PHYSICS, AND CHEMISTRY.

Translated for the Journal of the Franklin Institute.

### *Action of Light upon a Mixture of Perchloride of Iron and Tartaric Acid: Application to Photographic Printing.* Note of M. Poitevin.—*Academie des Sciences* (Paris), 21 January, 1861.

A long time since I observed that the salts of the peroxide of iron are reduced to the salts of the protoxide by light, in presence of certain organic substances, such as alcohol, ether, &c. As I was seeking to apply this property to photographic printing, I looked for reducing substances which were not volatile. The salts of the sesquioxide of uranium, which are themselves reduced by light, in presence of organic bodies (such as paper), react upon the per-salts of iron, by means of the protoxide of uranium which is at first formed. Acetate of ammonia, alloxanthine, glycerine, and especially tartaric acid, also furnished very distinct reactions which could be used in photography. Although this reduction is common to all the per-salts of iron, and even to the peroxide, which I also experimented upon, I confine myself to the use of a mixture of the perchloride of iron and tartaric acid, and shall speak of these substances only.

The partial formation of sesquigallate of iron on paper or other substances, for producing photographic pictures on them, is based upon the reduction of the sesquichloride of iron to protochloride, which takes place only at the points submitted to the action of the light.

The application of powdered charcoal or other coloring matters, and vitrifiable bodies, depend on another property, which, I believe, I was the first to observe: it is, that the perchloride of iron and tartaric acid dissolved in certain proportions and applied to a given surface, dried either spontaneously or artificially in the dark, give a uniform coat of a non-crystalline compound which is not hygroscopic, and remains thus so long as it is kept from the light; but which becomes deliquescent in the sun or in diffused light. I shewed, in the parts influenced by the light, the presence of the protochloride of iron which is deliquescent, and of a body of acid reaction which is very greedy of water, and which must have been formed by the reaction of chlorine upon tartaric acid; it is particularly this latter product which plays the most im-

portant part in the application of dry powders on photogenic surfaces, for when I reduce the dose of tartaric acid, there is not enough formed to fix the powder.

The following are the ways in which I operate:

1st. *For Printing by Gallate of Iron* (*common ink*).—I make a solution containing 10 grammes of perchloride of iron to 100 grammes of water; I add 3 grammes of tartaric acid, filter, and preserve from the light. To prepare the papers I pour this mixture into a dish, and apply successively each sheet, to its surface, taking care that no air-bubbles intervene; I withdraw it at once, and suspend it, in order to let it dry, in the dark; or after letting it drip, I dry it by the fire. The paper thus prepared may be kept for a long time; it is of a deep yellow color. To produce the picture, put it into the press under a photographic negative, or under the picture to be copied, and leave it exposed to the lights which penetrate the lights of the screen, until the yellow color has disappeared, and the picture in dark yellow appears on the whole ground of the paper; plunge rapidly the sheet into distilled water, then into a saturated solution of gallic acid, or an infusion of nut-galls, or into a mixture of gallic and pyrogallic acids, according to the tone of the black which you desire to get. In either case the organic acid forms ink only in the parts where the perchloride of iron has not been decomposed, and is without action on the protochloride which covers the parts on which the light has acted. To fix this picture it is sufficient to wash it with distilled or rain water.

2d. *Printing by Carbon and Powdered Colors; Photographic Stained-glass; Painting on Porcelain and Enamel.*—While practising the above mode of printing, I had remarked that the paper, after the impression had been made, had become very permeable to water in the insolated parts. I made use of this property in forming images with powders of various kinds. It sufficed for this purpose, to moisten the reverse of the sheet with gum water; this water passed through the paper and held the powder which was applied with a brush. Afterwards, by replacing the paper by surfaces of ground-glass, covering them with the above-mentioned mixture and drying them, I remarked that after their exposure to light, covered with a negative, the parts influenced, spontaneously covered themselves with moisture, and that the preparation from its original dryness had become deliquescent in those parts only; this led me to another mode of impression, which I will describe.

I make two solutions: one containing 16 grammes of perchloride of iron, the other 8 grammes of tartaric acid to 100 grammes of water; equal volumes of these two liquids are mixed in proportion as they are used. Upon surfaces of ground-glass, smoothed and perfectly cleaned, or on surfaces of polished glass previously covered with collodion or other basis, I pour the above mixture, spread it, and drip off the excess; I then allow these plates, laid either edgewise or horizontally, to dry either spontaneously or before the fire, according to the thickness of the coat which we desire to obtain. The plate when dried may be kept for a long time before using it. The printing is done through

a negative; it may require five or ten minutes in the sun, according to the season and the depth of the negative. In coming out of the press, the picture is scarcely visible on the plate, but becomes so very soon, by means of the coat of dampness which forms only on the parts impressed. This damp coating allows me to cause the adhesion of the powders wherever it exists, and the picture appears gradually under a brush charged with dry colors. The proof may be kept in this state; it is unchangeable, but it will be better to remove, first by acidified alcohol and afterwards by water, the parts of the impression not modified by light (they are but slightly soluble in pure water), then dry the plate and varnish the picture. A transparent picture is thus obtained. If a painting on glass is desired, mineral oxides or powdered enamels are employed for the powdering, and the sheets of glass are submitted in a muffle to a temperature sufficient to liquefy the flux or enamel; the same thing may be done on porcelain or enamelled surfaces.

When an impression on paper only is wanted, I employ powders of carbon, or other colors insoluble in water; I pour over the surface which has the picture, a solution of normal collodion, wash with acidulated water to remove the excess of the preparation and destroy the adherence of the collodion to the plate, and remove that coating by means of gelatine-paper. Not a trace of the picture remains on the glass. I gum or varnish the picture to secure it, and paste it upon card-board. I have also observed that this preparation by perchloride of iron and tartaric acid had the property of retaining fatty matters only upon the parts which have not received the light, and I have thus obtained a new means of printing by fat-inks and chemical engraving. —*Comptes Rendus.*

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## *The Patent Painted and Gilded Leather Cloth.*

From the London Builder, No. 933.

The majority of our readers have, doubtless, met with the patent leather cloth used to cover seats and otherwise, and many have seen it in its painted and gilded shape as manufactured by the Leather Cloth Company; nevertheless, they would probably be surprised, as we certainly were ourselves, to find a huge warehouse in Cannon-street West, filled with rolls of it. In France it has long been extensively supplied by this company, but here as yet it has only been occasionally used. In the new Westminster Palace Hotel, for example, it is hung in the smoking-room; and, at the Royal Hotel, Bridge-street, Blackfriars, in the billiard and reading-rooms. Many of the designs already produced are very elegant; and it may be made to present all the elegance of gilded leather, the *cuir doré* and the *cuir argenté* of the Middle Ages, while its cost is but trifling as compared with those hangings with which, as we know, in the sixteenth and seventeenth centuries all the houses of the Venetian nobles and gentry were hung. In England, too, it was greatly used, and examples may still be found in old houses. The cost of the painted and gilded leather cloth may

be called about 2*s.* 6*d.* a yard square, being enamelled by a patent process, which preserves the original beauty of the gilding, and allows it to be washed without injury. It is very durable, and it could be hung on new walls, on which it would not be safe to paint or put paper.

This company, who have manufactories also in France and Belgium, have large works at West Ham, where they employ about 150 men. Looking over their warehouse, we saw large quantities also of their vulcanized india rubber belting, which, as being more durable, appears to be fast superseding the leather belting.

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For the Journal of the Franklin Institute.

*Strength of Cast Iron and Wrought Iron Pillars:* A series of Tables deduced from several of Mr. Eaton Hodgkinson's Formulæ, showing the Breaking Weight and Safe Weight of Cast Iron and Wrought Iron Uniform Cylindrical Pillars. By Wm. Bryson, Civ. Eng.

D = diameter or side of the square of solid pillar in inches.
D = external diameter of hollow pillar in inches.
$d$ = internal diameter of hollow pillar in inches.
L = length or height of the pillar in feet.
W = breaking weight in tons.

*Hollow Uniform Cylindrical Pillars of Cast Iron with Both Ends Rounded.*

| Length in Feet. | Number of diameters contained in the length or height. | External diameter in inches. | Internal diameter in inches. | $W = 13\frac{D^{3.6} - d^{3.6}}{L^{1.7}}$ Breaking weight in tons. | $W = 13\frac{D^{3.76} - d^{3.76}}{L^{1.7}}$ Breaking weight in tons. |
|---|---|---|---|---|---|
| 8 | 32 | 3 | 2 | 15·18 | 18·54 |
| 9 | 36 | 3 | 2 | 12·43 | 15·09 |
| 10 | 40 | 3 | 2 | 10·39 | 12·64 |
| 11 | 44 | 3 | 2 | 8·83 | 10·73 |
| 12 | 48 | 3 | 2 | 7·62 | 9·25 |
| 13 | 52 | 3 | 2 | 6·65 | 8·08 |
| 14 | 56 | 3 | 2 | 5·86 | 7·12 |
| 15 | 60 | 3 | 2 | 5·21 | 6·33 |
| 16 | 64 | 3 | 2 | 4·67 | 5·67 |
| 17 | 68 | 3 | 2 | 4·21 | 5·12 |
| 18 | 72 | 3 | 2 | 3·82 | 4·64 |
| 19 | 76 | 3 | 2 | 3·49 | 4·23 |
| 20 | 80 | 3 | 2 | 3·19 | 3·88 |
| 21 | 84 | 3 | 2 | 2·94 | 3·57 |
| 22 | 88 | 3 | 2 | 2·71 | 3·30 |
| 23 | 92 | 3 | 2 | 2·52 | 3·06 |
| 24 | 96 | 3 | 2 | 2·34 | 2·84 |
| 25 | 100 | 3 | 2 | 2·18 | 2·66 |

*Solid Uniform Cylindrical Pillars of Cast Iron with Both Ends Rounded, and with Both Ends Flat.*

| Length in Feet. | Number of diameters contained in the length or height. | Diameter in inches. | Solid uniform cylindrical pillars of cast iron with both ends rounded. $W = 14{\cdot}9 \frac{D^{3\cdot76}}{L^{1\cdot7}}$ Breaking weight in tons. | Solid uniform cylindrical pillars of cast iron with both ends flat. $W = 44{\cdot}16 \frac{D^{3\cdot55}}{L^{1\cdot7}}$ Breaking weight in tons. |
|---|---|---|---|---|
| 8 | 32 | 3 | 27·03 | 63·60 |
| 9 | 36 | 3 | 22·12 | 52·06 |
| 10 | 40 | 3 | 18·49 | 43·52 |
| 11 | 44 | 3 | 15·73 | 37·01 |
| 12 | 48 | 3 | 13·56 | 31·92 |
| 13 | 52 | 3 | 11·84 | 27·86 |
| 14 | 56 | 3 | 10·43 | 24·56 |
| 15 | 60 | 3 | 9·28 | 21·84 |
| 16 | 64 | 3 | 8·31 | 19·57 |
| 17 | 68 | 3 | 7·50 | 17·65 |
| 18 | 72 | 3 | 6·81 | 16·02 |
| 19 | 76 | 3 | 6·21 | 14·61 |
| 20 | 80 | 3 | 5·69 | 13·39 |
| 21 | 84 | 3 | 5·24 | 12·33 |
| 22 | 88 | 3 | 4·84 | 11·39 |
| 23 | 92 | 3 | 4·48 | 10·56 |
| 24 | 96 | 3 | 4·17 | 9·82 |
| 25 | 100 | 3 | 3·89 | 9·16 |

*Solid Uniform Cylindrical Pillars of Wrought Iron with Both Ends Rounded, and with Both Ends Flat.*

| Length in Feet. | Number of diameters contained in the length or height. | Diameter in inches. | With both ends rounded. $W = 42{\cdot}8 \frac{D^{3\cdot76}}{L^{2}}$ Breaking weight in tons. | With both ends flat. $W = 133{\cdot}75 \frac{D^{3\cdot55}}{L^{2}}$ Breaking weight in tons. |
|---|---|---|---|---|
| 8 | 32 | 3 | 41·60 | 103·23 |
| 9 | 36 | 3 | 32·87 | 81·44 |
| 10 | 40 | 3 | 26·63 | 66·07 |
| 11 | 44 | 3 | 22·00 | 54·60 |
| 12 | 48 | 3 | 18·49 | 45·88 |
| 13 | 52 | 3 | 15·75 | 39·09 |
| 14 | 56 | 3 | 13·58 | 33·71 |
| 15 | 60 | 3 | 11·81 | 29·36 |
| 16 | 64 | 3 | 10·40 | 25·80 |
| 17 | 68 | 3 | 9·21 | 22·86 |
| 18 | 72 | 3 | 8·21 | 20·39 |
| 19 | 76 | 3 | 7·37 | 18·30 |
| 20 | 80 | 3 | 6·65 | 16·51 |
| 21 | 84 | 3 | 6·03 | 14·98 |
| 22 | 88 | 3 | 5·50 | 13·65 |
| 23 | 92 | 3 | 5·03 | 12·49 |
| 24 | 96 | 3 | 4·62 | 11·47 |
| 25 | 100 | 3 | 4·26 | 10·57 |

*Hollow Uniform Cylindrical Pillars of Cast Iron, with Both Ends Flat.*

| Length in Feet. | Number of diameters contained in the length or height. | External diameter in inches. | Internal diameter in inches. | $W = 44{\cdot}34 \frac{D^{3\cdot55} - d^{3\cdot55}}{L^{1\cdot7}}$ Breaking weight in tons. | $W = 42{\cdot}347 \frac{D^{3\cdot5} - d^{3\cdot5}}{L^{1\cdot63}}$ Breaking weight in tons. |
|---|---|---|---|---|---|
| 8 | 32 | 3 | 2 | 48·72 | 50·49 |
| 9 | 36 | 3 | 2 | 39·88 | 41·79 |
| 10 | 40 | 3 | 2 | 33·34 | 35·19 |
| 11 | 44 | 3 | 2 | 28·35 | 30·13 |
| 12 | 48 | 3 | 2 | 24·45 | 26·14 |
| 13 | 52 | 3 | 2 | 21·34 | 22·95 |
| 14 | 56 | 3 | 2 | 18·81 | 20 33 |
| 15 | 60 | 3 | 2 | 16·73 | 18·17 |
| 16 | 64 | 3 | 2 | 14·99 | 16·36 |
| 17 | 68 | 3 | 2 | 13·49 | 14·81 |
| 18 | 72 | 3 | 2 | 12·27 | 13 50 |
| 19 | 76 | 3 | 2 | 11·20 | 12 36 |
| 20 | 80 | 3 | 2 | 10 26 | 11·37 |
| 21 | 84 | 3 | 2 | 9·44 | 10·50 |
| 22 | 88 | 3 | 2 | 8·72 | 9·73 |
| 23 | 92 | 3 | 2 | 8·09 | 9·04 |
| 24 | 96 | 3 | 2 | 7·52 | 8·44 |
| 25 | 100 | 3 | 2 | 7·01 | 7·90 |

*Hollow Uniform Cylindrical Pillars of Cast Iron, with Both Ends Flat.*

| Length in Feet. | Number of diameters contained in the length or height. | External diameter in inches. | Internal diameter in inches. | $W = 46{\cdot}65 \frac{D^{3\cdot55} - d^{3\cdot55}}{L^{1\cdot7}}$ Breaking weight in tons. | $W = 44{\cdot}3 \frac{D^{3\cdot6} - d^{3\cdot6}}{L^{1\cdot7}}$ Breaking weight in tons. |
|---|---|---|---|---|---|
| 8 | 32 | 3 | 2 | 51·26 | 51·74 |
| 9 | 36 | 3 | 2 | 41·93 | 42·36 |
| 10 | 40 | 3 | 2 | 35·08 | 35·42 |
| 11 | 44 | 3 | 2 | 29 83 | 30·11 |
| 12 | 48 | 3 | 2 | 25·73 | 25·97 |
| 13 | 52 | 3 | 2 | 22·14 | 22 67 |
| 14 | 56 | 3 | 2 | 19·79 | 19·98 |
| 15 | 60 | 3 | 2 | 17 60 | 17·77 |
| 16 | 64 | 3 | 2 | 15·77 | 15·93 |
| 17 | 68 | 3 | 2 | 14·19 | 14·36 |
| 18 | 72 | 3 | 2 | 12 91 | 13·03 |
| 19 | 76 | 3 | 2 | 11·78 | 11·89 |
| 20 | 80 | 3 | 2 | 10·79 | 10 89 |
| 21 | 84 | 3 | 2 | 9·93 | 10 02 |
| 22 | 88 | 3 | 2 | 9 18 | 9·26 |
| 23 | 92 | 3 | 2 | 8·51 | 8·59 |
| 24 | 96 | 3 | 2 | 7·91 | 7·99 |
| 25 | 100 | 3 | 2 | 7·38 | 7·46 |

*Hollow Uniform Cylindrical Pillars of Cast Iron, with Both Ends Flat.*

| Length in Feet. | Number of diameters contained in the length or height. | External diameter in inches. | Internal diameter in inches. | $W = 46{\cdot}65 \frac{D^{3\cdot55} - d^{3\cdot55}}{L^{1\cdot7}}$ Breaking weight in tons. | Safe weight in tons. | Assumed breaking weight if irregularly set in tons. | Assumed safe weight if irregularly set in tons. |
|---|---|---|---|---|---|---|---|
| 8 | 32 | 3 | $1\frac{1}{2}$ | 61·43 | 15 35 | 20·47 | 5 11 |
| 9 | 36 | 3 | $1\frac{1}{2}$ | 50 28 | 12·57 | 16·76 | 4·19 |
| 10 | 40 | 3 | $1\frac{1}{2}$ | 42·14 | 10 53 | 14·04 | 3·51 |
| 11 | 44 | 3 | $1\frac{1}{2}$ | 35·76 | 8·94 | 11·92 | 2·98 |
| 12 | 48 | 3 | $1\frac{1}{2}$ | 30 84 | 7 71 | 10·28 | 2 57 |
| 13 | 52 | 3 | $1\frac{1}{2}$ | 26·92 | 6·73 | 8·97 | 2 24 |
| 14 | 56 | 3 | $1\frac{1}{2}$ | 23·73 | 5·93 | 7·91 | 1 97 |
| 15 | 60 | 3 | $1\frac{1}{2}$ | 21·10 | 5·27 | 7·03 | 1·75 |
| 16 | 64 | 3 | $1\frac{1}{2}$ | 18·91 | 4·72 | 6 30 | 1·57 |
| 17 | 68 | 3 | $1\frac{1}{2}$ | 17 05 | 4·26 | 5 68 | 1·42 |
| 18 | 72 | 3 | $1\frac{1}{2}$ | 15 48 | 3 87 | 5·16 | 1·29 |
| 19 | 76 | 3 | $1\frac{1}{2}$ | 14·12 | 3·53 | 4·70 | 1·17 |
| 20 | 80 | 3 | $1\frac{1}{2}$ | 12·94 | 3 23 | 4 31 | 1·07 |
| 21 | 84 | 3 | $1\frac{1}{2}$ | 11·90 | 2·97 | 3 96 | 0·99 |
| 22 | 88 | 3 | $1\frac{1}{2}$ | 11·00 | 2·75 | 3·66 | 0 91 |
| 23 | 92 | 3 | $1\frac{1}{2}$ | 10·20 | 2·55 | 3·40 | 0·85 |
| 24 | 96 | 3 | $1\frac{1}{2}$ | 9·49 | 2·37 | 3·16 | 0 79 |
| 25 | 100 | 3 | $1\frac{1}{2}$ | 8·85 | 2 21 | 2·95 | 0·73 |
| 26 | 104 | 3 | $1\frac{1}{2}$ | 8 28 | 2·07 | 2·76 | 0·69 |
| 27 | 108 | 3 | $1\frac{1}{2}$ | 7·76 | 1·94 | 2·58 | 0 64 |
| 28 | 112 | 3 | $1\frac{1}{2}$ | 7·30 | 1·82 | 2·43 | 0 60 |
| 29 | 116 | 3 | $1\frac{1}{2}$ | 6·88 | 1·72 | 2·29 | 0·57 |
| 30 | 120 | 3 | $1\frac{1}{2}$ | 6·49 | 1·62 | 2·16 | 0·54 |

*Hollow Uniform Cylindrical Pillars of Cast Iron, with Both Ends Rounded.*

| Length in Feet. | Number of diams. contained in the length or height. | External diameter in inches. | Internal diameter in inches. | $W = 13 \frac{D^{3\cdot6} - d^{3\cdot6}}{L^{1\cdot7}}$ Breaking weight in tons. | Safe weight in tons. |
|---|---|---|---|---|---|
| 8 | 16 | 6 | 4 | 184 08 | 46·02 |
| 10 | 20 | 6 | 4 | 125·97 | 31·49 |
| 12 | 24 | 6 | 4 | 92·43 | 23·10 |
| 14 | 28 | 6 | 4 | 71·11 | 17·77 |
| 10 | 17·143 | 7 | 5 | 200·72 | 50·18 |
| 12 | 20·571 | 7 | 5 | 147·16 | 36·79 |
| 14 | 24 | 7 | 5 | 113·23 | 28·30 |
| 16 | 27·428 | 7 | 5 | 78·52 | 19 63 |
| 12 | 18 | 8 | 6 | 218·73 | 54·68 |
| 14 | 21 | 8 | 6 | 168·35 | 42·08 |
| 16 | 24 | 8 | 6 | 134·16 | 33·54 |
| 18 | 27 | 8 | 6 | 109·72 | 27·43 |
| 14 | 16·8 | 10 | 8 | 321·75 | 80·43 |
| 16 | 19·2 | 10 | 8 | 256·36 | 64·09 |
| 18 | 21·6 | 10 | 8 | 209 82 | 52·45 |
| 20 | 24 | 10 | 8 | 175·37 | 43 84 |
| 16 | 16 | 12 | 10 | 430·82 | 107·70 |
| 18 | 18 | 12 | 10 | 352 69 | 88·17 |
| 20 | 20 | 12 | 10 | 294·84 | 73·71 |
| 22 | 22 | 12 | 10 | 250·64 | 62 66 |

*Hollow Uniform Cylindrical Pillars of Cast Iron, with Both Ends Flat.*

| Length in Feet. | Number of diameters contained in the length or height. | External diameter in inches. | Internal diameter in inches. | $W = 44{\cdot}34\,\frac{D^{3\cdot55} - d^{3\cdot55}}{L^{1\cdot7}}$ Breaking weight in tons. | Safe weight in tons. |
|---|---|---|---|---|---|
| 15 | 45 | 4 | 2 | 55·72 | 13·93 |
| 15 | 36 | 5 | 3 | 112·58 | 28·14 |
| 15 | 30 | 6 | 4 | 196·05 | 49 01 |
| | | | | $W = 42{\cdot}347\,\frac{D^{3\cdot5} - d^{3\cdot5}}{L^{1\cdot63}}$ | |
| 15 | 45 | 4 | 2 | 59·81 | 14·95 |
| 15 | 36 | 5 | 3 | 119·30 | 29 82 |
| 15 | 30 | 6 | 4 | 205·59 | 51·39 |
| | | | | $W = 46{\cdot}65\,\frac{D^{3\cdot55} - d^{3\cdot55}}{L^{1\cdot7}}$ | |
| 15 | 45 | 4 | 2 | 58 62 | 14·65 |
| 15 | 36 | 5 | 3 | 118·44 | 29 61 |
| 15 | 30 | 6 | 4 | 206·27 | 51·56 |
| | | | | $W = 44{\cdot}3\,\frac{D^{3\cdot6} - d^{3\cdot6}}{L^{1\cdot7}}$ | |
| 15 | 45 | 4 | 2 | 59·85 | 14·96 |
| 15 | 36 | 5 | 3 | 122·50 | 30·62 |
| 15 | 30 | 6 | 4 | 215·56 | 53·89 |

*Solid Uniform Cylindrical Pillars of Cast Iron, with Both Ends Flat.*

| Length in Feet. | Number of diameters contained in the length or height. | Diameter in inches. | $W = 44{\cdot}16\,\frac{D^{3\cdot55}}{L^{1\cdot7}}$ Breaking weight in tons. | Safe weight in tons. |
|---|---|---|---|---|
| 10 | 30 | 4 | 120·8 | 30·20 |
| 12½ | 30 | 5 | 182·6 | 45·65 |
| 15 | 30 | 6 | 255·9 | 63·97 |
| 17½ | 35 | 6 | 197·0 | 49·25 |
| 20 | 40 | 6 | 156·9 | 39·22 |

*Solid Uniform Cylindrical Pillars of Wrought Iron, with Both Ends Flat.*

| Length in Feet. | Number of diameters contained in the length or height. | Diameter in inches. | $W = 133{\cdot}75 \frac{D^{3{\cdot}55}}{L^2}$ Breaking weight in tons. | Safe weight in tons. |
|---|---|---|---|---|
| 10 | 30 | 4 | 183·5 | 45·87 |
| 12½ | 30 | 5 | 259·4 | 64·85 |
| 15 | 30 | 6 | 344·1 | 86·02 |
| 17½ | 35 | 6 | 252·8 | 63·20 |
| 20 | 40 | 6 | 193·5 | 48·37 |

NOTE.—In the above tables, the breaking weight is not critically correct for those pillars with *flat ends*, whose height is only 30 diameters.

In my calculations, I find that the breaking weight of pillars, as deduced from the formulæ for long flexible pillars with *flat ends*, is not correct, unless the height of the pillar is nearly 31 times its diameter.

*Hollow Cylindrical Pillars of Cast Iron, with Both Ends Flat.*

| Length in Feet. | Number of diameters contained in the length or height. | External diameter in inches. | Internal diameter in inches. | $Y = \frac{b\,c}{b + \frac{3}{4}c}$ Breaking weight in tons. | Safe weight in tons. |
|---|---|---|---|---|---|
| 8 | 24 | 4 | 3 | 100·07 | 25·01 |
| 8 | 19 1-5 | 5 | 4 | 160·94 | 40·23 |
| 8 | 16 | 6 | 5 | 229·22 | 57·30 |
| 8 | 13 5-7 | 7 | 5½ | 426·70 | 106·67 |
| 8 | 12 | 8 | 6½ | 539·67 | 134·91 |
| 8 | 10 2-3 | 9 | 7½ | 656·30 | 164·07 |
| 8 | 9 3-5 | 10 | 8½ | 774·87 | 193·71 |
| 8 | 8 8-11 | 11 | 9 | 1153·46 | 288·36 |
| 8 | 8 | 12 | 10 | 1313·65 | 328·41 |
| 8 | 7 5-13 | 13 | 11 | 1475·01 | 368·75 |
| 8 | 6 6-7 | 14 | 12 | 1635·95 | 408·98 |
| 8 | 6 2-5 | 15 | 12½ | 2197·02 | 549·25 |
| 8 | 6 | 16 | 13½ | 2398·52 | 599·63 |
| 8 | 5 11-17 | 17 | 14½ | 2596·32 | 649·08 |
| 8 | 5 1-3 | 18 | 15½ | 2800·97 | 700·24 |

NOTE.—The value of Y in the above formula is compounded of two quantities: $b$, the strength as obtained from one of the formulæ for long flexible pillars; and $c$, the crushing force.

The following tables show the breaking weight of uniform hollow cylindrical pillars of cast iron, deduced from several formulæ, and for different qualities of cast iron:—

Length or height of the pillar, 8 feet. External diameter, 18 inches. Internal diameter, 15½ inches.

| | |
|---|---|
| 2800·98 tons. | 2403·10 tons. |
| 2800·94 " | 2157·72 " |
| 2781·93 " | 2146·40 " |
| 2746·46 " | |

Length or height of the pillar, 10 feet. External diameter, 18 inches. Internal diameter, 15½ inches.

| | |
|---|---|
| 2641·49 tons. | 2114·46 tons. |
| 2641·15 " | 2061·84 " |
| 2616·51 " | 2046·79 " |

(To be Continued.)

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Translated for the Journal of the Franklin Institute.

## *New Investigations as to the Friction of Cars Sliding on the Rails of a Railroad.* By M. H. Bochet. *Acad. des Sciences de Paris,* 17 December, 1860.

In a preceding memoir presented to the Academy on the 26th April, 1858, I had already begun the question which I have since resumed in order to study it in a more extensive way; it is the results of this last investigation, altogether of an experimental nature, which I now communicate. Doubtless, I have not yet been able to grasp the problem of friction under all its possible circumstances; but I have attacked it in a great number of various cases, to wit: in the case of the sliding at all possible velocities from 0 to 25 metres per second, of iron with different degrees of polish, different woods, wet or dry, common or resinous, even of leather and gutta-percha, rubbing on surfaces of various sizes; always, it is true, by cars sliding over the rails of railroads, but on rails sometimes dry, sometimes wet, sometimes simply damp, sometimes even greased.

I have also been able to study, under the different circumstances indicated above, the question of the friction at starting.

In the first part of my memoir I describe in detail the process of experimental investigation which I followed, the rubbing apparatus which I employed, the dynamometer which I used to measure the resistance, the manner in which I was able to measure the velocity at each instant, and the precautions which I took to avoid the causes of error in the true values of the friction; I describe the mode adopted for the graphic representation of my experimental results, the method followed in each experiment, the various cases of friction examined, and the special conditions of my experiments upon the friction at starting.

In the second part, I present the results established by my experiments; these results are,

1. Want of constancy of the friction under the same circumstances

as far as they could be appreciated and defined in practice; so that the friction, even under circumstances practically identical, cannot be represented by a single curve, but only by a zone bounded by two curves, with a curve of the mean or more common friction under determinate circumstances.

2. The diminution of the friction in proportion as the velocity increases (all other things being the same) in all the cases which were examined.

3. Variation of the friction with the extent of the rubbing surfaces, all other things being equal, or otherwise expressing it, under the specific pressure. A variation which is insensible, so long as this specific pressure remains small, especially if, at the same time, the velocity is small; but sensible, if the velocity of the sliding is great, and especially when the specific pressure passes from large to small values. Whence it results, that the accepted law of the proportionality of the friction to the pressure, which is sensibly true under the ordinary circumstances of practice, cannot be considered as absolutely and generally exact. Yet the experiments related in my memoir, although sufficient to establish this fact, are not yet sufficient to allow us to deduce with precision the true law of the variation of the friction with the pressure.

4. A considerable variation in the friction of wood, according as the rails are dry, wet, or greasy; on the contrary, the complete insignificance of the state of dryness or moisture of the rails on the friction of iron; unimportance even of the state of greasiness, at the commencement of the sliding (before the production of an especial polish), unless the rubbing surface is relatively very small (as that of locked wheels) and the specific pressure consequently very great, in which case the friction of iron was very much diminished by a fatty lubric even at the beginning of the sliding.

5. A considerable influence of the condition as to polish, upon the friction; especially on that of iron; much less on that of wood.

6. The friction of wood much greater than that of iron, when dry.

7. The slight influence of the nature of the wood upon its friction; insensible when there is a lubric (except when the wood is resinous, and the lubric only water, in which case the friction is greater than in others); the influence of the nature of the wood only becomes sensible, though still slight, when the surfaces are dry; then tender woods produce a slightly greater friction than hard woods.

8. There was no especial friction at starting, except in the cases of wood and leather, upon wet or greasy rails; in all other cases (wood and leather upon dry rails, gutta-percha on rails dry or wet, iron on rails dry, wet, or greasy) the friction at starting was exactly the same at extremely small velocities (but of course greater than at notable velocities); on the contrary, for wood and leather on wet or greasy rails the friction at starting was, in the mean, double that corresponding to an extremely low velocity.

In a third part of my memoir, I have endeavored to give the explanation of the phenomena, and the laws of the friction which experiment

revealed. I have shown that we ought to admit three essential and general causes of friction, to wit: molecular attraction, the roughness of the surfaces, and the particular tearing which is produced in consequence of this, during the sliding; that the action of these three causes appears to explain the phenomena which friction presents. Not that I have been able to explain them all in this way, especially in all their details; but I believe that I have given a satisfactory and admissible explanation, in a general way only, of the most prominent phenomena, such as: 1, of the diminution of the friction as the velocity increases; 2, of the zones of friction; 3, of the influence of the nature of the material; 4, of the influence of the polish of the surfaces; 5, of the non-existence in general of an especial friction at starting. Some of the peculiarities which I have not explained, moreover, do not at all invalidate the general considerations which I have presented and which explain other facts.

In the fourth and last part, I show that all the values, very numerous, which I have obtained for the friction under the different circumstances, may be represented with sufficient approximation by the following formula, which is presented as being the simplest which can be adopted, so as to satisfy properly the condition of exactness.

$$f = p\left(\frac{k - y}{1 + a\,v} + y\right);$$

in which $f$ is the value of the friction; $p$ represents the total pressure under which the sliding took place; $k$ and $y$ are two co-efficients variable with the circumstances, the value of $k$ being always greater than $y$; $a$ is a third co-efficient, perhaps slightly variable, but if so, by a law which is still entirely unknown and not even suspected; but perhaps also constant, and at all events which may be assumed constant with a sufficient approximation in practice, and then it is equal to 0·3 when the velocity is expressed in metres per second.

As to the co-efficients $k$ and $y$, they vary separately with the substances which slide upon each other, with the degree of polish of their surfaces, the presence or absence of a lubric between these surfaces, and the nature of this lubric, and also with the specific pressure under which the sliding takes place. We can only give tables of the numerical values of $k$ and $y$ for determinate conditions and states. I have given a considerable number, deduced from positive experiments. To give an idea of the principal circumstances, I may say that the greatest frictions being those of wood, and especially soft wood, leather, and gutta-percha, on dry rails, without lubric, $k$ sometimes rose to 0·70 and was never below 0·40, and most frequently was 0·60 for tender woods and 0·55 for hard woods. The friction of iron was always less; it is true, that in exceptional cases when the iron was of very coarse and wrinkled surface, $k$ sometimes rose to 0·60, but habitually it was not above 0·40, and sometimes fell to 0·25. When the iron had a surface even imperfectly polished, $k$ never rose above 0·40, and was generally not more than 0·20 or 0·30, and sometimes fell to 0·17 and even to 0·12 (indifferently too, as to whether the rails were dry or

moist or even greasy, except in the latter case, when the rubbing surface was relatively small, that is, when the specific pressure was great; then the co-efficient of friction of iron with a greasy lubric was very much diminished). In the friction of wood and leather with a greasy lubric, $k$ generally fell to 0·16, sometimes only to 0·20, but sometimes too to 0·05. Moreover, the grease always favored the rapid production of polish on the surfaces, and consequently the diminution of friction in this way. It is principally thus, and consequently indirectly, that the greasy lubrics act to diminish the friction.

It is especially at the starting and at very low velocities that the frictions differ very much from each other, according to the circumstances: In proportion as the velocity increases, the different frictions, all diminishing, ordinarily in proportion to their value, generally approximate to each other.

This approach to a common value takes place also the more, in proportion as the rubbing surfaces are more polished, which condition is best produced and maintained by lubricating the surface with a greasy substance.

Thus we may say that all substances well polished sliding rapidly, and under a moderate specific pressure, have all nearly the same very small co-efficient of friction. But outside of this very peculiar combination of circumstances, nothing is more changeable with the conditions than friction.

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## *Patera's Process for Extracting Silver from its Ores.* By Clement Le Neve Foster.

From the Journal of the Society of Arts, No. 422.

The process in question was originally suggested by Dr. Percy, F. R.S., of the Government School of Mines, and has been of late years taken up and carried out on a large scale by one of the most celebrated metallurgical chemists in Austria, viz., Herr von Patera. This process is of special interest, on account of the analogy it presents with the well-known "fixing" in photography, which is nothing more than dissolving out the chloride of silver (which has not been acted on by light) by means of hyposulphite of soda.

In the metallurgical process this property is made use of in the following manner:—The ores which contain the silver in combination with sulphur, or with sulphur and arsenic, are roasted with green vitriol and common salt, and thus is produced a chloride of silver which may be dissolved out by a solution of hyposulphite. The silver can then be precipitated by sulphide of sodium, falling down as sulphide of silver. All that is necessary to be done then is to heat the sulphide in a muffle in contact with the atmosphere; the sulphur escapes in the form of sulphurous acid, and the silver remains in the metallic state. It is then melted in plumbago pots and cast into ingots for the mint. Such is a rough outline of the process which is now, and has been for some years, in operation at Joachimsthal, on the northern frontier of Bohemia. The ores which are subjected to this process are rich in silver,

containing on an average two per cent., but often as much as ten per cent. Ores containing less than one per cent. are melted down with pyrites in a cupola blast furnace for regulus or *matte*, which is then treated as the ore.

The advantages of this process are manifold: 1st, ores containing large amounts of arsenic can be thus successfully treated, when Ziervogel's process would fail; 2d, the expense of heating a strong solution of salt, as in Augustin's process, is got rid of, as the hyposulphite is used cold; 3d, the hyposulphite filters quicker and better than the brine in Augustin's process, for the dissolving power of hyposulphite being great, a weak solution may be used; 4th, the solution of hyposulphite may be used over and over again, for it is being continually renewed, and as this is one of the peculiar points in the process, it deserves particular attention. The precipitation of the silver is effected, as has been before stated, by sulphide of sodium, and this is a polysulphide, for it is prepared by calcining soda with sulphur and then boiling it with sulphur. In this manner a polysulphide of sodium is formed, but in contact with the air some hyposulphite of soda is generated, and thus, each time that the silver is precipitated, some hyposulphite of soda is added to the solution. In this way Herr von Patera, who commenced with 14 lbs. of hyposulphite of soda (and who yearly extracts more than 3000 lbs. of silver), has never needed a fresh supply, and has, in fact, been obliged to throw away quantities of solution, as his stock was always increasing. The expense of this process is not great; the extraction of a pound of silver from the ore costs, on an average, only 9*s*. 9*d*., whilst by the method of smelting formerly in use, the cost of production of a similar quantity of metal was no less than 16*s*.

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For the Journal of the Franklin Institute.

*Strength of Materials:* Deduced from the latest experiments of Barlow, Buchanan, Fairbairn, Hodgkinson, Stephenson, Major Wade, U. S. Ordnance Corps, and others. By CHAS. H. HASWELL, Civil and Marine Engineer.

No. 7.

(Continued from page 252.)

### DEFLECTION OF BARS, BEAMS, GIRDERS, &c.

From the experiments of Barlow on the deflection of wood battens, he deduced that the deflection of a beam from a transverse strain, varied as the breadth directly and as the cubes of both the depth and length, and that with like beams and within the limits of elasticity it was directly as the weight.

These deductions are supported by the particular experiments referred to, and although they have been subsequently supported by the experiments of Hodgkinson on cast iron bars, having like conditions of proportionate section to length, an extended examination of the subject, aided by further elements, will show that, however correctly these

laws may apply in the cases referred to, they are inapplicable in varied conditions of section, length, and material.

If the lines of deflection of bars, beams, &c., were right lines, meeting at the point of bearing of the stress, or in other words, in the neutral axis of the section at that point, the deflection would be directly as the resistance of the bar, beam, &c., to transverse stress, inasmuch as the point of rupture of the fibres, or of the material of the bar, &c., would depend upon the angle of the bar, at the point of the application of the stress, and the measure of the angle, being the versed sine of it, would be the same, without reference to the length of the bar, as in like angles, the versed sines are directly as the length of their bases. Thus, if the deflection of a bar, 10 feet in length between its supports, was 5·25 inches, the angle of deflection from a horizontal plane would be five degrees; *hence*, the angle of deflection at any other length would be the same, and, consequently, the resistance of a bar, &c., to deflection alike to that of transverse strain, would be directly, as its length. It occurs, however, that the line of deflection is that of a curve; *hence*, although the angle of rupture, measured from the neutral axis of the section of the bar, &c., would be the same, yet this angle, in consequence of the curvature of the plane of the bar, &c., will be depressed in proportion to the curvature, and whilst it remains the same, the deflection or versed sine of the angle of the neutral axis of the section and the plane of the bar, &c., at the points of support, will be increased proportionate to the versed sine of the arc of curvature.

Therefore, in bars, beams, &c., of an elastic material, and having great length compared to their depth, the deductions of Barlow will apply with sufficient accuracy for all practical purposes; but in consequence of the varied proportions of depth to length of the varied character of materials, of the irregular resistance of beams constructed with scarphs, trusses, or riveted plates, and of the unequal deflection at initial and ultimate strains, it is impracticable to give any positive laws regarding the degrees of deflection of different and dissimilar bars, beams, &c.

In the experiments of Hodgkinson, it was further shown that the sets from deflections was very nearly as the squares of the deflections.

In a rectangular bar or beam, the position of the neutral axis is in its centre, and it is not sensibly altered by variations in the amount of strain applied. In bars or beams of cast and wrought iron, the position of the neutral axis varies in the same beam, and is only fixed whilst the elasticity of the beam is perfect. When a bar or beam is bent so as to injure the elasticity of it, the neutral line changes and continues to change during the loading of the beam until it breaks. When a beam is supported at the ends and loaded in its middle with different small weights, they are reciprocally proportional to the radius of curvature at that point, and the curvature itself is consequently proportional to the weight.

*When a Bar or Beam is fixed at one End and loaded at the Other*, the fundamental property of the curve of deflection is, that the curva-

ture at every point is as the distance of that point from the line of direction of the weight.*

The quantity of extension in consequence of the imperfect elasticity of the fibres of materials is very irregular, and after a certain deflection has been obtained, it is subject to no determinate law; but while the weight or strain upon the fibres is considerably less than that which is required to produce fracture, the law of deflection for each case is nearly uniform, and proportional to the exacting force.

When beams are of the same length, the deflection of one, the weight being suspended from one end, compared with that of a beam uniformly loaded, is as 8 to 3, and when a beam is supported at both ends, the deflection in like cases is as 5 to 8.

*Whence*, if a beam is in the first case supported in the middle and the ends permitted to deflect, and in the second, the ends supported and the middle permitted to descend, the deflection in the two cases is as 3 to 5.

Of three equal and similar beams, one inclined upward, one inclined downward at the same angle, and the other horizontal, it has been determined that that which had its angle upward was the weakest, the one which declined was the strongest, and the one horizontal was a mean between the two.

When a beam is *uniformly loaded*, the deflection is as the weight, and approximately as the cube of the length, or as the square of the length and the element of deflection and the strain on the beam, the weight being the same, will be but one-half of that when the weight is suspended from one end.

The deflection of a beam *fixed at one end* and *loaded at the other*, compared to that of a beam of twice the length *supported at both ends* and *loaded in the middle*, the strain being the same, is as 2 to 1, and when the length and the loads are the same, the deflection will be as 16 to 1, for the strain will be four times greater on the beam fixed at one end than on the one supported at both ends; therefore all other things being the same, the element of deflection will be four times greater: also, as the deflection is as the element of deflection into the square of the length, *then*, as the lengths at which the weights are borne in their cases are as 1 to 2: the deflection is as $1 : \overline{2^2 \times 4} = 1$ to 16.

The deflection of a beam having the section of a triangle, and supported at its ends, is one-third greater when the edge of the angle is up, than when it is down.

*When the Length is Uniform*, with the same weight, the deflection will be inversely as the breadth and square of the depth into the element of deflection, which is itself inversely as the depth. *Hence*, every thing else being the same, the deflection will vary inversely as the breadth and cube of the depth.

*Illustration.*—The deflections of two pine battens, of uniform breadth and depth, and equally loaded, but of the lengths of 3 and 6 feet, were as 1 to 7·8.

If a beam is cylindrical, the deflection is 1·7 times that of a square beam, other things being equal.

* See Barlow on Materials and Construction, p. 67.

The following are the deductions of Mr. Barlow consequent upon the preceding:

*When a Beam is Fixed at one End and Loaded at the Other.*

$$\frac{l^3 \text{ W}}{b\ d^3 \text{ D}} = \text{V, a constant quantity.}$$

*When a Beam is Fixed at one End and Uniformly Loaded.*

$$\frac{3\ l^3 \text{ W}}{8\ b\ d^3 \text{ D}} = \text{V}.$$

*When Fixed at Both Ends and Loaded in the Middle.*

$$\frac{l^3 \text{ W}}{24\ b\ d^3 \text{ D}} = \text{V}.$$

*When Supported at Both Ends and Loaded in the Middle.*

$$\frac{l^3 \text{ W}}{16\ b\ d^3 \text{ D}} = \text{V}.$$

*When Supported at Both Ends and Uniformly Loaded.*

$$\frac{5\ l^3 \text{ W}}{8 \times 16\ b\ d^3 \text{ D}} = \text{V}.$$

*When Supported in the Middle and the Ends Uniformly Loaded.*

$$\frac{3\ l^3 \text{ W}}{5 \times 16\ b\ d^3 \text{ D}} = \text{V}.$$

*When Supported at Both Ends and the Weight Suspended from any other Point than the Middle.*

$$\frac{m^2\ n^2 \text{ W}}{l\ b\ d^3 \text{ D}} = \text{V}.$$

*l representing the length in inches, b its breadth, d its depth,* W *the weight or strain with which it is loaded, m n the distances of the weight from the supports, and* D *the deflection in inches.*

*Hence*, in order to preserve the same stiffness in beams, the depth must be increased in the same proportion as the length, the breadth remaining constant.

The deflection of different beams arising from their own weight, having their several dimensions proportional, will be as the square of either of their like dimensions.

NOTE.—In the construction of models on a scale, intended to be executed in full dimensions, this result should be kept in view.

With regard to the ultimate deflection of beams before their rupture, the same relations do not exist, as when the depth is the same, the element of deflection will, in the breaking state of a beam, be constant; consequently, the ultimate deflection will, in this case, be as the square of the length, and it will be inversely as the depth, when the length is the same; and if both these dimensions remain constant, the last deflection will be constant also, whatever may be the breadth of the beam.

TABLE *of the Results of Experiments on the Deflection of Battens, Bars, Beams, and Girders of Various Sections and Materials;* observed by Major Wade, U. S. Ordnance Corps, Barlow, Buffon, Fairbairn, Hodgkinson, Stephenson, &c., &c.,

*Bar, Beam, &c., Supported at Both Ends, Weight or Strain applied in the Middle.*

| MATERIAL AND SECTION. | Length of bearing. | Breadth. | Depth. | Depth of opening. | Weight. | Deflection. | Value for general use. $\frac{l^3 \text{ W}}{16\, b\, d^3 \text{ D}} = \text{V}.$ |
|---|---|---|---|---|---|---|---|
| WOODS. | Ft. Ins. | Inch. | Inch. | Inch. | lbs. | Inch. | |
| Fir. Rectangle, | 3 | 1·5 | 2· | — | 120 | ·090 | 187 |
| Square, | 4 | 2· | 2· | — | 420 | ·360 | 292 |
| Rectangle, | 4 | 3· | 1·5 | — | 120 | ·270 | 153 |
| " | 6 | 3· | 1·5 | — | 120 | ·937 | 170 |
| " | 6 | 1·5 | 3· | — | 120 | ·260 | 154 |
| " | 6 | 1·5 | 2· | | 120 | ·680 | 198 |
| " | 8 | 3· | 1·5 | — | 120 | 2·045 | 185 |
| " | 10 | 1·5 | 3· | — | 120 | 1·050 | 177 |
| Ash. Cylinder, | 3 10 | 2· | 2· | — | 715 | 2·700* | 58 |
| Hollow do., | 3 10 | 2· | 2· | ·5 | 657 | 2·500* | 58 |
| Square, | 7 | 2· | 2· | — | 75 | ·422 | 238 |
| " | 7 | 2· | 2· | — | 225 | 1·266† | 238 |
| Yellow Pine. Square, | 5 | ·75 | ·75 | — | 16 | 1·500 | 250 |
| " | 5 | ·75 | ·75 | — | 40 | 6·250* | 158 |
|  . . . . | 5 | 1·5 | 1·5 | — | 16 | ·190 | 133 |
|  . . | 5 | 1·5 | 1·5 | — | 16 | ·310 | 80 |
| Square, | 7 | 2· | 2· | — | 150 | 1·134† | 178 |
| Elm. Square, | 6 | 2· | 2· | — | 125 | 1·685† | 62 |
| Beech. Square, | 7 | 2· | 2· | — | 150 | 1·026† | 196 |
| Oak. Square, | 3 | 1· | 1· | — | 158 | 2·950 | 91 |
| " | 7 | 2· | 2· | — | 150 | 1·590† | 146 |
| " | 6 | 2· | 2· | — | 200 | 1·280† | 132 |
| " | 15 | 5·35 | 5·35 | — | 6000 | 8·570 | 180 |
| " | 30 | 5·35 | 5·35 | — | 2330 | 19·780 | 240 |
| Rectangle, | 2 | ·75 | 1·5 | — | 323 | 1·500 | 43 |
| Pine. Rectangle, | 40 | 7·5 | 9·25 | — | 1700 | 5·250 | 218 |
|  " | 40 | 7·5 | 9·25 | 4·625 | 1700 | 3·500 | 327 |
| " | 40 | 7·5 | 18·5 | 9·25 | 1700 | 2·250 | 63 |
| " | 40 | 7·5 | 22·375 | 13·125 | 1700 | 1·125 | 72 |
| METALS. | | | | | | | |
| Cast Iron, English. | 2 10 | 1· | 1· | — | 300 | ·160† | 2607 |
| " | 2 10 | 1· | 1· | — | 1008 | ·625 | 2278 |
| Mean English, | 4 6 | 1· | 1· | — | 471 | 1·675 | 1589 |
| Swedish.‡ | 3 | 1· | 1· | — | 884 | ·500† | 2983 |
| English. Square, | 4 6 | 1· | 1· | — | 56 | ·135 | 2551 |
| " | 4 6 | 1· | 1· | — | 112 | ·259 | 2362 |
| " | 4 6 | 1· | 1· | — | 448 | 1·535 | 1634 |
| " | 4 6 | 1· | 1· | — | 440 | 1·779* | 1432 |
| " | 6 9 | 3· | 3· | — | 112 | ·012 | 2219 |
| " | 9 | 2· | 2· | — | 112 | ·167 | 1910 |
| Mean of mixture and blasts, do., | 4 6 | 1· | 1· | — | 481 | 1·366* | 1992 |
| English. Square, | 13 6 | 3· | 3· | — | 112 | ·092 | 2311 |
| Rectangle, | 10 | 2· | 1· | — | 56 | ·480 | 3660 |
| " | 13 6 | 3· | 1·5 | — | 56 | ·323 | 2634 |
| " | 13 6 | 6· | 1·5 | — | 56 | ·165 | 2573 |

* Breaking weight. † Elasticity perfect.

‡ Barlow deduced from this that, as a mean, 1000 lbs. is the load that will destroy the elasticity of a bar of wrought iron 1 inch square and 3 feet long between the supports; and Mr. Drewry assumes that a like bar will be deflected a quarter of an inch by 560 lbs., and that it is not safe to load it permanently with 266 lbs.

TABLE *of the Results of Experiments on the Deflection of Battens, &c.*, (*Continued*).

| MATERIAL AND SECTION. | Length of bearing. | Breadth. | Depth. | Depth of opening. | Weight. | Deflection. | Value for general use. $\frac{l^3 \text{W}}{16\, b\, d^3\, \text{D}} = \text{V}.$ |
|---|---|---|---|---|---|---|---|
| METALS (Continued). | Ft. Ins. | Inch. | Inch. | Inch. | lbs. | Inch. | |
| American mean, 2d fusion. Square. | 1 8 | 2· | 2· | — | 10800 | ·117† | 1656 |
| 3d " " | 1 8 | 2· | 2· | — | 9000 | ·088‡ | 1840 |
| Chilled, " | 1 8 | 2· | 2· | — | 10800 | ·051‖ | 3821 |
| Dry sand, " | 1 8 | 2· | 2· | — | 10800 | ·110 | 1761 |
| Green sand, " | 1 8 | 2· | 2· | — | 5000 | ·045† | 2000 |
| 2d fusion. Cylinder, | 1 8 | 2· | 2· | — | 10800 | ·161§ | 1205 |
|  . . | 4 6 | 2· | 1·43 | — | 168 | ·106 | 2467 |
| Hot blast. Square, | 5 | 1· | 1· | — | 225 | ·110¶ | 1562 |
| Cold " " | 5 | 1· | 1· | — | 225 | ·085¶ | 2008 |
| 20 p. c. wrought iron, " | 4 6 | 1· | 1· | — | 112 | ·202 | 3189 |
| 10 " " " | 4 6 | 1· | 1· | — | 511 | 1·500 | 1940 |
| 2·5 " nickel, " | 2 3 | 1· | 1· | — | 860 | ·520* | 1180 |
|  Flanch 5· × ·3 | { 6 6 | ·36 | 1·55 | — | 112 | ·273 | 5302 |
| | { 6 6 | ·36 | 1·55 | — | 336 | 1·030 | 4191 |
|  " " | { 6 6 | ·36 | 1·55 | — | 112 | ·270 | 5302 |
| | { 6 6 | ·36 | 1·55 | — | 336 | ·895 | 4850 |
|  " 1·5 × ·5 | 3 1 | ·5 | 3· | — | 672 | ·027 | 3360 |
|  " " | 3 1 | ·5 | 3· | — | 672 | ·025 | 3609 |
|  " " | 3 1 | ·5 | 3· | — | 2016 | ·079 | 3534 |
|  " " | 3 1 | ·5 | 4·** | 1·5 | 2016 | ·051 | 2302 |
|  " " | 3 1 | ·5 | 3·** | 1 5 | 2016 | ·052 | 5364 |
|  " 23·9 × 3·125 | 23 1 | 3·29 | 36·1 | — | 60000 | ·100 | 2983 |
| " " " | 23 1 | 3·29 | 36·1 | — | 136000 | ·230 | 2940 |
| " " " | 23 1 | 3·29 | 36·1 | — | 230000 | ·420 | 2720 |
| " " 6·5 × 1· area 18·5 | 15 | ·91 | 14· | — | 4480 | ·300 | 1261 |
|  " 4·5 × ·875 9· × 1·25 | 22 | 1·12 | 36· | — | 22400 | ·094 | 3034 |
| " " 9· × 1·625 18· × 2·75 | 50 | 2· | 36· | — | 22400 | ·187 | 9618 |
| " " 4·125 × 1·5 15· × 2·25 | 30 9 | 1·5 | 24·5 | — | { 44800 | ·469 | 7998 |
| | | | | | { 72000 | ·870 | 6817 |
|  " 2·72 × ·83 5·9 × 8·4 area 18·1 | 15 | ·68 | 17·25 | — | 4480 | ·150 | 1808 |

* Breaking weight. † Elasticity perfect. ‡ ·020. ‖ ·003. § ·022 ¶ Permanent set. ** Depth of opening, 3 ins.

TABLE *of the Results of Experiments on the Deflection of Battens, &c., (Continued).*

| MATERIAL AND SECTION. | Length of bearing | Breadth. | Depth. | Depth of opening. | Weight. | Deflection. | Value for general use. $\frac{l^3 \text{ W}}{16\ b\ d^3 \text{ D}} = \text{V}.$ |
|---|---|---|---|---|---|---|---|
| METALS (Continued). | Ft. Ins. | Inch. | Inch. | Inch. | lbs. | Inch. | |
|  Flanch. 1·6 × ·315 4·16 × ·53 | 4 6 | ·38 | 5·125 | — | 11186 | ·400 | 3113 |
| " " 2·3 × ·28 6·61 × ·54 | 4 6 | ·34 | 5·125 | — | 12087 | ·260 | 5783 |
| " " 2·25 × ·33 6· × ·74 | 7 | ·4 | 4·1 | — | 2900 | ·250 | 9023 |
| " " 2·15 × ·24 7·60 × ·72 | 4 6 | ·39 | 5·125 | — | 12800 | ·250 | 5552 |
| " " do., | 9 | ·40 | 5·125 | — | 10500 | 1·450 | 6128 |
|  Rectangular, area 1·965 | 4 6 | ·975 | 2·015 | — | 712 | ·280 | 1817 |
|  Open beam, area 2· | 4 6 | 1· | 2·5 | ·50 | 712 | ·132 | 1965 |
| " " | 4 6 | 1· | 3· | 1· | 712 | ·085 | 1766 |
| " " | 4 6 | 1· | 4· | 2· | 712 | ·040 | 1582 |
| Curved bars, versed sine 1·44 in. | 9 | 1· | 3· | — | 1456 | ·38 | 6464 |
| " " ·63 in. | 9 | 1· | 3· | — | 1778 | ·61 | 4919 |
| Wrought Iron. Square, | 2 9 | 2· | 2· | — | 2240 | ·068 | 2677 |
| " | 2 9 | 2· | 2· | — | 4480 | ·128 | 2748 |
| Round, | 5 6·5 | 1·25 | 1·25 | — | 58 | ·125 | 1965 |
| Rectangle, | 2 9 | 1·5 | 3· | — | 2240 | ·074 | 970 |
| Swedish. Square, | 5 6·5 | 1· | 1· | — | 58 | ·125 | 4812 |
|  Flanch. 4·5 × ·5 Rib, 3·25 diam., | 10 3 | ·5 | 10· | — | 3136 | ·375* | 11258 |
|  " 3·5 × ·6 | 2 7 | ·8 | 3·5 | — | 6720 | ·033 | 6384 |
|  Flanch. 2·75 × 1· 4·3 × ·44 | 10 | ·35 | 8· | — | 4360 | ·12 | 12674 |
| | | ·35 | 8· | — | 12980 | ·3 | 15058 |
|  " 2·85 × ·41 | 4 | ·29 | 2·5 | — | 1960 | ·240 | 7209 |
|  Flanches, 2 of 2·25 × ·28 do. 2·25 × ·3 | 7 | ·25 | 7· | — | 16480 | ·250 | 16479 |
|  Flanch 6 × ·375 12 × 3·75 Angle iron, 2·5 × 2·5 × ·5 3·5 × 3·5 × ·5 | 28 6 | ·375 | 12·5 | — | 13000 | 1· | 2653 |
|  Flanch 12 × ·375 4 × ·375 Angle iron, 2·5 × 2·5 × ·375 1·75 × 1·75 × ·375 | 28 6 | ·375 | 12·125 | — | 20700 | 2·250† | 19911 |

* Permanent set. † Ibid, ·4375.

TABLE *of the Results of Experiments on the Deflection of Battens, &c.,* (*Continued*).

| MATERIAL AND SECTION. | Length of bearing. | Breadth. | Depth. | Depth of opening. | Weight. | Deflection. | Value for general use. $\frac{l^3 \text{W}}{16\ b\ d^3 \text{D}} = \text{V}.$ |
|---|---|---|---|---|---|---|---|
| METALS (Continued.) | Ft. Ins. | Inch. | Inch. | Inch. | lbs. | Inch. | |
| Flanches, 9 × 16 ins., Angle iron, 4 × | 40 5 | ·75 | 24· | — | 35000 | 1·250‡ | 11196 |
| Tubes, thickness ·03 in. | 3 9 | 1·9 | 3· | — | 448 | ·100 | 287 |
| " " ·1325 in. | 7 6 | 3·9 | 6· | — | 4376 | ·240 | 570 |
| " " ·124 in. | 30 | 15· | 24· | — | 5685 | ·490 | 96 |
| " " ·250 in. | 30 | 15·5 | 23·75 | — | 5685 | ·210 | 220 |
| " " ·525 in. | 30 | 15 5 | 24· | — | 5685 | ·120 | 372 |
| " top, ·437 in. " bottom, ·272 in. | 30 | 15·75 | 23·75 | — | 33685 | ·850 | 316 |
| " ·037 in. | 17 | 12· | 12· | 11·925 | 2755 | ·650* | 62 |
| " " ·0954 in. | 31 | 24· | 24· | 23·81 | 10236 | ·630* | 91 |
| Box girder with angle iron at angles. top plates ·375 bot. & sides ·125 | 9 | 6· | 6· | — | 7000 | ·250 | 984 |
| Corrugated plates, | 31 6 | 3·1 | 8· | — | 4480 | ·62 | 8893 |
| Tubes, thickness, ·0416 in. | 17 | 9·25 | 14·62 | 13·535 | 2262 | ·620* | 38 |
| " " ·143 in. | 17 5 | 9·75 | 15· | 14·714 | 16800 | 1·390* | 123 |
| Steel, Cast. Soft, | 3 2 | ·23 | ·52 | — | 22 | ·331 | 4245 |
| Razor, | 2 2 | ·30 | ·57 | — | 22 | ·083 | 2984 |
| Brass. Cast, | 1 | ·7 | ·45 | — | 60 | ·040† | 1469 |
| GUN METAL. | | | | | | | |
| Copper 8. Tin 1, | 1 | ·7 | ·5 | — | 100 | ·050† | 1428 |

*Breaking weight. †Elasticity perfect. ‡Permanent set, ·625.

(To be Continued.)

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## *On a new Alkali-Metal.* By MM. BUNSEN and KIRCHHOFF.

From the Lond. Chemical News, No. 51.

In a recent number of the *Philosophical Magazine* there is given an account of some researches by MM. Bunsen and Kirchhoff on the effect produced by various metals on the spectrum of a flame in which their chlorides are volatilized. That part of their investigation which is more particularly interesting consists of a method of photo-chemical analysis of exquisite delicacy, which the authors have specially studied in relation to the alkali-metals.

These metals have been employed in the form of chlorides, which

have been purified with the greatest care. When these are introduced into a jet of flame they volatilize to a greater or less extent, and then communicate to the flame the special character above alluded to, and which is observable when the spectrum produced by the flame is examined by a sufficient magnifying power.

The above-named memoir is accompanied by a colored plate which illustrates the spectra of the alkali-metals with their characteristic rays. These rays are the more visible in proportion as the flame is less luminous and its temperature higher. The ordinary Bunsen gas-burner answers admirably for these experiments. The rays shown by the chlorides of potassium, sodium, and lithium are perfectly well defined; those of barium, strontium, and calcium are more complicated, and require a somewhat experienced eye for their identification. They are, however, quite distinct enough to be easily recognised, even when salts of these metals are mixed together; for the great advantage of this method of analysis is, that foreign matters have no influence on the results, the authors being able to detect with certainty the different elements in a mixture containing the tenth of a millegramme of the metals mentioned above. Sodium, with its yellow ray, first appears; after that the well defined red ray of lithium; next is seen the paler rays indicating potassium; and, after these rays have disappeared, they are replaced by those of calcium and strontium, which remain visible for some time. The absence of one or other of these sets of rays shows the absence of the corresponding metals.

We are, then, by this method placed in possession of an analytical process of the most extraordinary delicacy. The researches of our authors prove that this sensibility almost approaches the infinite, the eye being able, by its means, to recognise the presence of the three-millionth part of a millegramme of chloride of sodium. It must not, therefore, be a matter of surprise to find sodium distributed almost everywhere, especially in the atmosphere, in which is almost always a sufficient quantity to show the sodium ray. The same may be said in great measure of lithium. In a room of a capacity of about 60 cubic metres was exploded a mixture of sugar-of-milk and chlorate of potassa, containing 9 millegrammes of carbonate of lithia. The lamp, being placed at some distance off, became quickly colored, so that the red ray could be distinctly visible in the spectrum. The authors estimated that this sensibility reached the nine-millionth part of the amount taken.

After this it must not be a matter of surprise to find that lithium is one of the widest-spread elements. The water of the Atlantic was found to contain it. It was also found in the ashes of plants grown on a granite soil, in the vine, in tobacco, and also in milk and in human blood. In the mother-liquors of tartaric acid manufactories, the lithia is found to be so concentrated as to be worth commercial extraction; and the same may be said of certain mother-liquors of saline springs.

With so delicate a reaction as the one just described, of an almost infinite sensibility, and applicable to all metals, the presence of ele-

ments, existing in so small quantities as to entirely escape ordinary analysis, may be rendered visible. Many observations tended to this point, and MM. Bunsen and Kirchhoff now announce definitely (*Annal. der Physik und Chemie*) that they have discovered a new alkali-metal, the fourth member of the group of potassium, sodium, and lithium. At present they have only found it in very small quantities in the mineral water of Kreuznach, in the saline water of Dureckeim, and in one of the sources of the Bade—the Umgemach.

The chloride of the new metal differs from those of sodium and lithium by the yellow precipitate which it produces in the presence of bichloride of platinum. It is distinguished from potassium by its nitrate being soluble in alcohol. Introduced into a flame, and examined with a prism, the vapors of the new chloride show a very interesting spectrum, consisting of two blue lines, one of which, the fainter, almost corresponds with the blue of strontium; the other, also a well defined blue line, is situated a little further towards the violet extremity of the spectrum, and rivals the lithium line in brightness and distinctness of outline.

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## *On the Surface-Condensation of Steam.* By J. P. JOULE, LL.D., F. R. S.

From the Lond. Artizan, Feb., 1861.

In the author's experiments steam was passed into a tube, to the outside of which a stream of water was applied, by passing it along the concentric space between the steam tube and a wider tube in which the steam tube was placed. The steam tube was connected at its lower end with a receiver to hold the condensed water. A mercury gauge indicated the pressure within the apparatus. The principal object of the author was to ascertain the conductivity of the tube under varied circumstances, by applying the formula suggested by Professor Thomson,

$$c = \frac{w}{a} \log \frac{V}{v},$$

where $a$ is the area of the tube in square feet, $w$ the quantity of water in pounds transmitted per hour, V and $v$ the differences of temperature between the inside of the steam tube, and the refrigerating water at its entrance and its exit. The following are some of the author's most important conclusions.

1. The pressure in the vacuous space is sensibly the same in all parts.

2. It is a matter of indifference in which direction the refrigerating water flows in reference to the direction of the steam and condensed water.

3. The temperature of the vacuous space is sensibly equal in all its parts.

4. The resistance to conductivity must be attributed almost entirely

to the film of water in immediate contact with the inside and outside surfaces of the tube, and is little influenced by the kind of metal of which the tube is composed, or by its thickness up to the limits of that of ordinary tubes.

5. The conductivity increases up to a limit as the rapidity of the stream of water is augmented.

6. By the use of a spiral of wire to give a rotary motion of the water in the concentric space, the conductivity is increased for the same head of water.

The author, in conclusion, gives an account of experiments with atmospheric air, as the refrigerating agent; the conductivity is very small in this case, and will probably prevent air being employed for the condensation of steam except in very peculiar circumstances.

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## *Incrustation in Steam Boilers.* By Henry Ransford.

From the Journal of the Society of Arts, No. 424.

All the world knows that the incrustation in steam boilers is deposited from the water, and that, in tubular boilers, it is very difficult to get rid of; but few are aware that "blowing out" a boiler, to get rid of the sediment on the bottom, hardens the sediment that adheres to the tubes, converting it into a calcareous shell, requiring a smart blow of a hammer to dislodge it.

Will you oblige me by giving to the world, through the columns of your *Journal*, a very simple and efficacious remedy?

I tried the experiment on a 30-horse tubular boiler. In addition to the blow-off cock at the bottom another was fitted over the fire-pan, at the usual level of the water, and to the end of it, inside the boiler, was screwed on a funnel of sheet iron, partly flattened, so that, on the cock being opened, anything floating within eight or ten inches on each side was drawn through.

The engine-driver had directions to open the lower cock once a day, and the upper one when he saw the water in the glass gauge was thick, and keep them open until the water ran clear, but never to blow out the boiler as formerly. Three or four gallons from the lower, and half that quantity from the upper cock was sufficient to carry off all thick and dirty water.

At the end of *three months*, first allowing the water to get nearly cold, the boiler was emptied; a stream of water was then introduced by the man-hole, and the tubes thoroughly washed. On examination the under half of the tubes was as clean as the day they were made, the upper half discolored, but no scale, and the sides of the boiler in a similar state; on the bottom was about a half bushel of thin scale, broken up into small pieces, that apparently had fallen or been washed from the tubes; thus, after three months' work, there was nothing to do but to get up steam again.

The secret consists in never blowing out the boiler when hot, the usual custom, as the result is—the heat of the tubes and sides instan-

taneously convert the soft deposit into a hard calcareous substance, and every time the boiler is blown out an additional stratum is added. If the man-hole is taken off on Saturday afternoon, and the flues opened, the water is cold enough to run off by Monday morning, so that no time is lost, and I have no doubt the hot water might be allowed to run off on the Saturday provided an equally large stream of cold water was allowed to run in at the same time, until the boiler and tubes were cold. I will merely add, the water was pumped from the Thames, and allowed to settle, before being used for the boiler. There is no reason why the plan should not answer equally well for locomotives.

Brompton, Dec. 19th, 1860.

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For the Journal of the Franklin Institute.

## *The Manufacture of Cast Iron Pipes.* By Ed. Brandt, Esq.

At the expense of much time, and subjecting myself to no inconsiderable labor and inconvenience, I have been enabled to accumulate the annexed particulars, which were the prominent features embodied in a Report upon the manufacture of cast iron pipes, submitted by John H. Rhodes, Esq., Inspector, &c., to the Chief Engineer of the Water Works, Brooklyn, New York. It deserves the closest perusal of all who are in any way whatever connected with water pipe castings, as its descriptions of the defects most usual, with those that only periodically and under certain circumstances occur, are clearly given, together with such rules and suggestions as will enable manufacturers to avoid them in the future.

As it will be observed, the Report compares the vertical pipe castings with the horizontal, and advocates the former.

The acceptance of defective castings and their use in the pipe distribution of a city, create, sooner or later, leaks and breaks in the works of which they become a part, causing much trouble and expense to the public; therefore, that intelligence which will cause the arrest of such imperfections in the manufacture of cast iron pipes should commend itself to the attention of public authorities, as well as that of manufacturers, inspectors, &c.

Mr. Rhodes says:

Sir:—Having concluded the duties to which I was ordered by you, I now present my Report, together with such information in reference thereto as I have been enabled to obtain.

In the course of the discharge of my duties, I have found a great proportion of the work so faulty as to lead me to a critical examination of the manner of manufacturing, and the cause of the defects. The proportion of bad pipes which I have from time to time met with has been so great (sometimes as high as 50 per cent.) as to create great doubt as to whether the remainder would be practically safe, although showing no defects to the eye or weakness under the application of the required pressure. I have observed, and hereafter shall endeavor

to show, that in casting pipes horizontally, difficulties present themselves which are almost insurmountable. A perfect pipe cast in this manner is the exception and not the rule, inasmuch as these difficulties are in themselves, not mechanical but natural, and are peculiar to the manner of moulding and casting it. I shall further endeavor to show that the main difficulties met with, in casting pipes horizontally, may be avoided by casting vertically, thereby insuring the greatest degree of safety and durability.

In accordance with your orders, I proceeded to the foundry of Messrs. Colwell & Co., at Conshohocken, Pa., on the day appointed, to inspect and prove the pipes under the contract of Messrs. H. S. Welles & Co., for the Brooklyn Water Works, where I continued to discharge that duty for six consecutive months, during which time I inspected and proved 6432 pipes, consisting of 3369 6-in., 2230 8-in., 423 20-inch, and 250 30-inch, rejecting, upon inspection under proof, 158 6-inch, 98 8-inch, 58 20-inch, and 14 30-inch. A very considerable number in addition, were rejected without subjecting them to the proof. The above were rejected from one or more of the following causes, viz: blisters, sand holes, shrinkage cracks, air cells, and cold shuts.

The 6-inch and 8-inch pipes were cast in green sand moulds with green sand cores, placed horizontally. These were more particularly liable to defects from sand holes and shrinkage cracks, and occasionally from blisters; the first being caused from the cutting of the cores, or moulds, or both, from the abrasion of the hot metal in flowing through the mould, or by the core or mould having been injured or loosened in closing the flask. Many are also objectionable from their uneven thickness. The cause of these difficulties being attributable, in a great measure, to the *manner* of moulding and casting them, will be more particularly explained hereafter.

The 20-inch and 30-inch pipes were cast vertically with the "hub" end down in "dry sand moulds" and "loam cores." The loss upon these was mainly attributable: 1st, to an intermixture of sand or scoria with the iron; 2d, the washing off of the blacking from the mould or core, not unfrequently forming a "parting" of the iron nearly or quite through the thickness of the pipes; 3d, "cold shuts" in the body of the pipe; 4th, shrinkage recesses in the "hub"; 5th, "air cells" through the centre of its thickness; the latter being caused principally by an improper admixture of the sand used in forming the mould. One, and the great cause of failure in casting pipes vertically, may be found in the fact that the casting is not poured with sufficient rapidity, but by dribbling the iron through a back runner until the mould is half filled, then pouring the residue from above through small gates or openings, and an insufficient number of them has necessarily led to the castings being imperfect from "cold shuts," "air cells," and not unfrequently a large recess in the "hub," almost hidden from sight. This may be readily explained in this way: the iron having poured too long from the back runner, making the heat intense at the point of its connexion with the "hub" long after the rest of the pipe had

chilled, leaving, consequently, no means for the shrinkage at that point to receive metal to fill the space made by its contraction.

Subsequently to the visit made at Conshohocken, I received your orders to proceed to the works of the Warren Foundry and Machine Co., N. J., who were then engaged in casting 6-inch, 8-inch, 12-inch, 20-inch, 30-inch, and 36-inch pipes for the Brooklyn Water Works. Upon entering on my duties there, I found 107 6-inch, 53 8-inch, and 24 12-inch pipes ready for inspection. Upon examination I accepted but 62 of the 107 6-inch, but 19 of the 53 8-inch, and 7 of the 24 12-inch. The proportion of perfect pipes was so small as to create no inconsiderable excitement within myself, and very great apprehension among the stockholders of the Company; so much so, that after a few subsequent trials they gave up as impracticable the casting of small pipes as a source of profit, believing that they would not be able to fulfil the contract for that class of pipes without subjecting themselves to great loss.

The manner of moulding these differed materially from those cast at Conshohocken. They were cast in "green sand moulds" and "loam core," set up at an angle of about ten degrees, poured from one end of the flask. A very large proportion of them were "blistered." "Sand holes" were common, and the "cope," or tops of the pipes were very thin near their centre of length, caused by the springing of the "core bar," and that difficulty being frequently increased by the scorching of the straw rope while in process of drying, thereby causing it to loosen and rise upon the bottom and sides of the "core bar" by the pressure of the surrounding iron while being cast, or it may be very thin from the "boiling" of the metal in consequence of the core not being dry. It is thus evident that an accurate judgment is necessary in preparing the cores. I shall refer to this part of the subject and explain more fully hereafter.

I now come to the consideration of the 20-inch, 30-inch, and 36-inch pipes, which were so successfully cast at this foundry by Messrs. Firth & Ingham, who were sub-contractors with the Warren Foundry & Machine Co., to cast these pipes and deliver them ready for inspection. To this firm is essentially owing the great success which has been achieved in casting the force mains and large branches for the works. I take great pleasure in having an opportunity to state that they have scarcely lost a pipe in casting that has not been owing to improper material accidentally furnished them.

These pipes have undergone a very severe inspection and proof, in effecting which (although the loss, if rejected, fell upon them), I have always received their hearty co-operation, and I have to record that I have not in a single instance known them to make an attempt to conceal imperfections; upon the contrary, they were gentlemanly and communicative upon all matters relevant to my duties, and I have derived from them great practical information. I have here inspected 112 20-inch pipes, rejecting 2; 113 30-inch pipes, rejecting 2; 74 36-inch pipes, rejecting 4; 32 30-inch bevel hubs, rejecting 1; 40 36-inch bevel hubs, rejecting 1; force mains 1½-inch thick, 196 36-inch, re-

jecting 4; force mains $1\frac{3}{8}$-inch thick, 158 36-inch, rejecting 8; force mains $1\frac{1}{4}$-inch thick, 356 36-inch, rejecting 4; force mains $1\frac{1}{8}$-inch thick, 126 36-inch, rejecting 5. (I am led to believe, upon examination, that the strongest and soundest pipe of 36-inch diameter is much in favor of a weight not variable far from 3600 to 4000 lbs.) Increased care became necessary in order to make sound castings $1\frac{1}{2}$ inches thick, as the increased thickness caused the centre of the pipe (in reference to thickness) to remain much longer in a fluid state, and particularly so at the "hub" end, where there is a very much larger amount of metal that in shrinking was continually drawing from the centre of the pipe (in thickness), rendering it necessary to "churn" the runners and continue the supply of hot metal for some time after the cast was "up."

I believe that 36-inch pipes of over 3600 lbs. weight might be cast to advantage six inches over the required length, to be subsequently cut off in a lathe. Had this course been followed, we should have lost none of that diameter, as I have met with no unsoundness in that class of pipes which has extended more than that distance from the spigot end, rarely more than two inches.

Having thus had an opportunity of comparing the relative merits of the various modes or plans pursued in casting iron pipes, I am fully convinced from my experience that *all* pipes, large or small, should be cast *vertically*. In order to show how I have been thus convinced, I will make a comparison between "green sand" pipes, cast horizontally or inclined, and "dry sand" pipes, cast vertically. In order to do so, I will now give a particular description of, and examine:

First, the defects of the system of making "green sand" pipes with "*loam* cores."

Second, the defects of the system of making "green sand" pipes with "*green sand* cores."

Third, I will endeavor to show how their defects may be avoided by casting pipes vertically in "dry sand moulds" and "loam cores."

First.—The defects of the system of making "green sand" pipes with "loam cores" are so various, that in order to explain them clearly, it will be necessary to examine them in detail. For that purpose I will classify them as follows, viz:

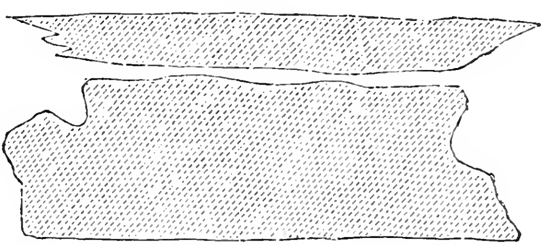
1. Their tendency to unevenness in thickness.
2. The cause of "blows" or "blisters."
3. The causes that tend to weaken the side of the pipe lying uppermost in the mould.

*First.* Green sand pipes with loam cores, are generally uneven in thickness, often to the extent of one-half or more of the required thickness of the pipe. This unevenness is caused in at least five different ways, and each of these causes of irregularity may be at work together or separately.

1. The spring of the core bars by the lift on them. On a 12-inch core, when the pipe is cast at the usual angle of about ten degrees, it is about 3100 lbs., the weight of the core is about 700 lbs., so that the effective lift upon the core is about 2400 lbs. The lift upon an 8-inch core is about 900 lbs., and of a 6-inch core about 500 lbs. The spring of a 12-inch core bar is so small as to be of little importance, but as you decrease that diameter it becomes very considerable. The spring of an 8-inch core bar varies from $\frac{1}{16}$th to $\frac{1}{8}$th of an inch; a 6-inch core bar will spring from $\frac{1}{16}$th to $\frac{2}{16}$ths of an inch, and below that diameter it becomes necessary to use chaplets or nails.

2. The rising of the loam or coating on the bar. This may be caused by running the straw ropes on the core bar too close together, or through the ropes being too soft, or not drawn sufficiently tight; and as any of these evils are much easier upon the workmen than the proper way, they are often indulged in; but the principal cause of the rising of the loam core is the burning of the ropes in the drying oven by what is called "scorching or high drying," the object of which is to prevent "blisters" on the pipe. The adhering principle of loam is a vegetable matter which burns with the heat of the iron, thereby generating a gas, which is one of the principal causes of "blisters," and by scorching the core they thereby avoid a portion of it; but in scorching the loam they also scorch the straw rope, so that the base of the loam is partially destroyed, and the pressure of the iron (when casting the pipe) forces the loam close to the bar, and as the pressure of the iron acts upon the bottom of the core first, and then upon the sides, as it rises in the mould, the loam is wrapped close to the bottom and sides of the bar, and is consequently lifted upon the top, where it remains; for the pressure upon the iron at the bottom is greater than upon the top of the mould, and to that extent will the pipe be thinner upon the top than upon the bottom. The larger the diameter of the core, the greater the evil from the core rising from this cause.

Fig. 1.



The above diagram shows the full size of a specimen taken from the top and bottom side of a 16-inch pipe cast for the Hoboken Water Works.

3. The manner of securing the cores. They are wedged down at the ends by wooden wedges driven under the wooden handles of the flask, while the bearing of the core is a "sand print" of a few inches

in length. If they are wedged down too tight the core is forced too low, and if not wedged tight enough the core will rise. This is done with but little judgment, commonly by men who do not know how much the core will lift, or what pressure they are putting on the wedge.

4. It is common to set the core a little below the centre in the mould, as the core might rise, or the bar might spring, or the loam might rise upon the bar, and under any circumstances the top of the pipe is weaker than the bottom, and if a little thicker it would help it. With this system of moulding, it appears to me to be good judgment to place the core at least 20 per cent. of the thickness below the centre, being thus obliged at the outset to consent to and desire an uneven thickness of pipe at the ends in order to obtain the greatest mean strength.

As the transverse weakness of a pipe is mainly caused by the action of shrinkage (in an uneven pipe), it may be almost to a breaking point, and yet not be discovered until after the pipe has been laid in the ground, when its weight may cause them to break. If the pipe be uneven to a very considerable extent, and the shrinkage has dangerously affected it, it will not be straight, having been drawn from a straight line as follows: The side of the pipe that is thinnest will cool first and contract before the thick side; the thick side being in a semi-fluid state will yield to the strain; but the thick side must shrink also, at which time it will be found that the thin side has cooled and refuses to give way in turn, but the shrinkage will go on, and the pipe assumes a curved form, the heavy or thick side forming the concave. The above description holds good when the mould has been straight and the core placed nearer one side than the other, as in the case when a core rises in a "green sand" mould, or is set out of centre in a "dry sand" vertical mould.

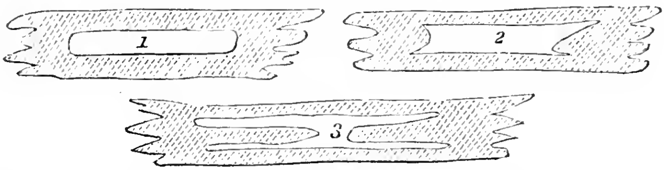
But a pipe cast as before described, does not always assume a curved form, as the moulder not unfrequently takes the advantage of turning the mould over when hot, whereby the thin or "cope" side is covered by the hot sand, while the "drag," which is thickest, is exposed to the action of the air, and thereby cools much faster than the thin side, which is protected by the hot sand, in which case the curve may be so little as to be scarcely discernible. Still the pipe remains uneven in thickness, and should it be of small diameter and thin, the bending tendency will much weaken the pipe on the thin side, and in a manner that cannot be discovered by the present manner of proving by the press, as the very means taken to procure the pressure insures its safety, for its only tendency is to a transverse fraction.

5. In clamping the moulds. This evil is not so common as the others; and when a mould is clamped thin, it is caused by carelessness or laziness. With care and judgment this evil may be avoided.

*Secondly.* The cause of "blows" or "blisters." The cause is not very easily described, but its appearance and characteristics I will endeavor to explain and show. A blister is simply a recess in the body of the pipe, covered by a shell inside and out, and frequently giving no sign of its presence, particularly to one not thoroughly practised

in their search. They assume all imaginable forms; some appearing under certain circumstances as follows:

Fig. 2.




And they may be found from the size of a pea, extending to several inches in length. The shell covering varies in thickness, but will commonly be from $\frac{1}{16}$th to $\frac{3}{16}$ths of an inch. In a pipe one-half inch thick, the blisters are invariably on that side of the pipe cast uppermost, commonly called the "cope," and may be found any where in the direction of its length, but generally about the middle. These blisters will occur when the core is not thoroughly dry, or when the loam is "too close," or if there be too much vegetable matter in the loam. Again, a pipe is almost sure to blister if it is poured with "dull" iron, or if it be poured slow, even with iron tolerably "sharp."

In connexion with the above, there would seem to be a fact overlooked by moulders generally, which has much to do with the difficulties which have presented themselves; it is this: "dull" iron has less specific gravity than "sharp" iron. This may be questioned, but can be easily accounted for. It is shown practically in casting pipes, and is subject of proof if necessary. The difference in weight between sharp and dull iron, is not so great as to cause the iron in a mould or ladle to assume a level just in proportion to its temperature immediately, for the reason that iron is so heavy that it requires no inconsiderable force to set it in motion, the difference in the specific gravity not being sufficient to create a rapid circulation; but should the current of circulation favor the "dull" iron, being uppermost, it will assuredly maintain that position. In order to render this more intelligible, I will endeavor to illustrate the effect by giving a description of casting a pipe which fails to run to completion. Suppose we undertake to pour a green sand pipe at the usual angle for "loam" cores, from the *bottom* of the mould: the iron which first enters through the gate will be cooled in its passage over the cold mould, and rises to give place to the hot iron following, which is continued to be displaced by the current of incoming hot iron. The iron which first entered, will be the "dullest," and consequently the lightest, and will keep uppermost as it is pressed up by the under-current of hot metal, until it finally becomes chilled and will run no further, in which case the pipes will not be run complete, which is no uncommon occurrence; but should you run the pipe from the *top* of the mould this difference is partially avoided, and only partially, for the iron falls to the bottom side of the mould as soon as it enters, and the whole current runs down the mould under the core until it reaches the lower end of the mould, or to the level of the iron in the mould, as the case may be.

It may be readily seen, from the fact of the hot iron all running down under the core, and the dull iron, being lightest, that the last will rise upon the opposite side: hence it will be seen that all the dull or chilled iron will be upon the line of the top of the pipe, and as dull iron is more favorable for the production of blisters than sharp, it becomes one of the causes of blisters in the top of pipes.

The most prolific causes of blisters are produced by a steam arising from a damp core, or the gas generating from the burning of the vegetable matter contained in the loam from which the core is made; there not being sufficient pressure in the mould at the time the gas is generated to force it through the loam to the holes in the core bar intended as its means of escape; it consequently forces itself into the iron, which it can more readily displace while the pressure of the iron is low. The specific gravity of the gas being so much less than the iron, it makes its way to the top, let it be projected from which point of the core it may, and as I have before shown, the dullest iron in the mould is on the top of the core; this dull iron sets rapidly around the gap, as in Fig. 2 (No. 1); or if the pressure is "up" before the iron sets, the gas may be compressed a little, and a portion of the iron flow back into the space, as in Fig. 2 (No. 2); or the pressure may be sufficiently strong to force a portion of the gas through the iron into the "green sand," or back again into the core, and leave a blister similar to that in Fig. 2 (No. 3). Or, as is sometimes the case, the blister will be entirely filled up, leaving the shell of the blister unmelted, in which case the shell can be knocked off, and the iron under it will show conclusively that it is a second run.

I will endeavor to explain why it is that blisters are generally found at about the centre of length of the pipe. In drying the cores in the oven, the outside of the cores is about equally exposed to the heat, but that is not so with the inside. It will be easily observed that the dampness will pass off in the form of steam much more readily from the ends of the bar than from the middle, by means of which the ends get a little more firing than the middle. This, together with the greater pressure upon the bottom of the pipe, would seem to account for the ends being more free from blisters than the middle.

Another difficulty is frequently met with by not having the cores dry, which produces a boiling of the metal upon the upper surface of the core, leaving the pipe very thin. The subjoined diagram is taken full size from a specimen of pipe six inches in diameter.

Fig. 3.


*Thirdly.* I will now review the causes which tend to weaken the top of a pipe cast inclined or horizontal.

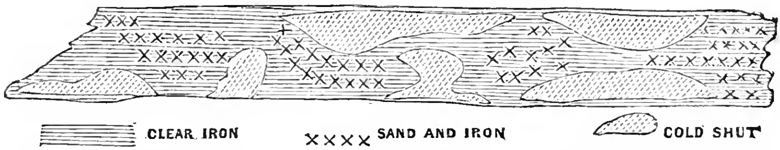
1. The unequal thickness.

I observe that every thing that tends to make a pipe uneven, does to that extent make the upper portion of it thin, and this tendency is so great that I will venture to say that if one hundred of the pipes cast under this system were broken, not one of them would be found

equal in thickness from end to end, and many of them would vary from 25 to 50 per cent. below the required thickness.

Again, into that part of the pipe which is liable to be thinnest is floated the dullest iron, and the pressure put on so slow in pouring, that the iron is liable to become set before it is pressed compactly together. The evil effects of this are shown by the liability of the pipes to be blistered and "cold shut," and all the particles of sand that wash from the mould, together with the blacking washed from the core, with whatever "slag" gets into the mould, or dirt thrown out by the iron while it is burning, is floated to the top of the pipe, causing that portion of it to become dirty, porous, and thin, with an occasional "cold shut."

Fig. 4.




The above diagram is made from a specimen taken from an 8-inch pipe. This pipe bore the pressure of 300 lbs. to the square inch, but was rejected from the discovery, at the distance of only two feet, of a place similar to the one submitted above; neither of them leaked. Now, it may be asked, how is it that with all these defects the pipes are enabled to sustain the pressure applied to them? The answer is simply this: The pipes are made of a thickness to meet the exigencies of the manufacture, and the amount added for the life of them, and for the risk attending such defects, gives a large margin in excess of what would be necessary for the required strength merely. I am required to put a pressure of 300 lbs. per square inch upon a 36-inch pipe, its thickness slightly less than an inch; and put the same amount of pressure upon a 12-inch pipe, its thickness one-half of an inch (which is very light for that diameter), yet, in proportion to its' diameter, it is 50 per cent. heavier than the one 36 inches in diameter. But the latter pipe cast vertically is infinitely the safest, as is shown by inspection.

(To be Continued.)

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Translated for the Journal of the Franklin Institute.

## *Defective Insulation by Gutta-Percha.* By J. M. Gaugain.

In a former note I gave the *co-efficients of charge* of wires of small diameter, such as are employed for aerial telegraphs; and I also endeavored to determine these co-efficients for the cables which are used for sub-marine communications; but I here found an unexpected difficulty. I found that the gutta-percha which forms the outer envelope of the conducting wire possesses a very appreciable conducting power. The existence of this conduction renders it impossible to determine the *co-efficient of charge* accurately, and destroys all interest in such determination.

If the substance surrounding the conducting wire were perfectly insulating, the cable, when once plunged into the water, would form a true Leyden jar, of which the coating would be, on one side the conducting wire, and on the other the water surrounding the cable; the condensation produced by the influence of the water on the wire, would modify its *co-efficient of charge*, but the law of transmission would still be expressed by the very simple formula which I have before given, and consequently the time of propagation would remain proportional to the square of the length of the conductor.

But when the envelope of the wire possesses an appreciable conducting power, the formula which I allude to cannot be applied, and it becomes necessary to take into account the loss which is established throughout the length of the wire.

I will cite some experiments which will show the kind of absorption which the gutta-percha exerts under the circumstances of which I speak. These experiments were performed on two cylindrical condensers which differ from each other only by the nature of the substance interposed between the coatings. One of the two is only an end of a telegraphic cable formed by a copper wire and an envelope of gutta-percha; in the other, the gutta-percha has been replaced by gum-lac. In both, the exterior coating is made of a thin sheet of tin, applied upon the surface of the insulating envelope. The thickness of this envelope is 5 mm. (0·2 in.), the diameter of the wire is 1 mm. (0·04 in.), the length of each condenser is about 50 centim. (20 in.) The following are the results which I got in comparing these two apparatus:

1. When the gum-lac condenser was charged by putting the interior wire into communication with the source, and the external coating in communication with the ground, the charge which either coating takes is nearly independent of the time during which the condenser remains in contact with the source. *It is altogether different with the gutta-percha condenser; the charge which this apparatus receives varies, and very notably, according to the time during which it is left in communication with the source. It requires more than a quarter of an hour to saturate the apparatus*, and the maximum charge may be double or triple that which is obtained when the communication is established but for a few seconds.

The maximum charge of the gutta-percha condenser is, however, greater than that which the gum-lac condenser takes under the same conditions.

2. When the gum-lac condenser has been charged, and a metallic communication is established between its coatings, the maintenance of this communication for a few seconds is sufficient to discharge the apparatus completely. When, on the contrary, it is desired to discharge completely the gutta-percha condenser after saturation, it will be found necessary to maintain the communication for more than a quarter of an hour.

It evidently results from these observations that gutta-percha possesses considerable conducting power, which allows it slowly to absorb the electricity and to return it. I have before observed that this pro-

perty differs in different specimens, and I will here add, that in the same specimen it also changes very notably with the temperature.

It appears to me certain, that this kind of absorption of which I have spoken, is produced in submerged telegraphic cables, as well as in the condensers upon which I experimented, and it will easily be conceived that it is injurious. In fact, when the circuit is closed at one station, the wire must first be charged more or less completely, before the current can act on the receiving apparatus, and consequently the absorption must retard the transmission of signals. Again, when the circuit is opened, the gutta-percha, which is, so to speak, saturated with electricity, restores it, and the receiver continues to receive a current after the transmitting station has ceased to send one. These inconveniences will be felt more severely in proportion as the wires in operation are larger, and I think that we ought to endeavor to avoid them. We will succeed by applying upon the wire a coating of very insulating varnish to separate it from the gutta-percha. The whole difficulty consists in finding a varnish which will insulate sufficiently. The different varnishes may be very easily tried by the experimental process which I have used.—*Cosmos*, February, 1861.

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Translated for the Journal of the Franklin Institute.

## *Explosion of a Steam Boiler.*

M. Jobard has given to the Academy of Sciences at Paris, the following account of an explosion which took place at Mæstrich, by which the proprietor and engineer, who had taken advantage of the stoppage of the works for the purpose of taking the measures inside of the furnace for a new grate, were killed.

"When the workmen go to dinner, the fireman covers the grate with the siftings, closes the register of the chimney and the furnace door, and often places a plate of sheet-iron before the opening of the ash-pan, for the purpose of preserving his fire by stopping the draft. At the first sound of the recall-bell, the fireman ought at once to open the chimney-register, so as to discharge the gases which have been produced in this sort of retort; the air of the ash-pan soon becomes filled with the hydrogen gas which fills the furnace, flues, and every part accessible to flames. This mixture of air and hydrogen constitutes a kind of *fire-damp* perhaps even more dangerous than that of the mines, because it is heated.

"The engineer must have neglected to discharge this gas before opening the furnace-door, with a lamp in his hand; hence the explosion which lifted up the boiler, and burst it at its weakest part.

"I have every reason to believe that the greater part of the explosions have a similar cause to that which I have suggested; for almost all the accounts in the Journals begin with these characteristic words, 'At the moment when they were about to recommence work in the establishment of X———, a terrible explosion was heard; happily the workmen had not yet returned.'

"Who does not see that at the first blow of the bell, the fireman

begins to rake his fire, so as to start the engine, forgetting first to open the chimney: a precaution which he thinks unimportant because he has frequently neglected it without becoming a victim, for the mixture is not always in explosive proportions. The narrative does not fail to add, that the boiler was lifted from its seat, which would not happen if the explosion had not taken place in the furnace; the second explosion, which is confounded with the first, is that of the boiler itself, brought about by the shock of the first." *Comptes Rendus*, 4th Feb. 1861.

M. Jobard is a man of experience and ingenuity, and we call attention to this account, because the custom which he explains is a dangerous one, and the precautions which he indicates are very proper and even necessary. But we differ from him entirely as to his supposition that this is the general explanation to be given of explosions which happen when starting a steam engine. In the first place, these frequently occur under circumstances where such an explanation is inadmissible, and are clearly due to the fact that, the water has gradually been evaporating from the boiler during the rest of the machine, and none has been supplied; and secondly, we do not understand how under ordinary arrangements, an explosive mixture can leak from the top of the furnace into the ash-pan, through a bed of hot coals, without burning, and this would consume all the explosive mixture, as it was generated. As to the throwing 'the boiler from its seat,' this is easily explained by the reaction of the steam issuing into the furnace, and against the bottom of the ash-pan, and takes place whenever the fracture takes place in the lower part of the boiler. Ed.

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*A Constant Copper-Carbon Battery.*—By Julius Thomsen.

From the Lond. Ed. and Dub. Phil. Mag., January, 1861.

In the ordinary galvanic apparatus, zinc usually officiates as positive element. This metal is, however, readily attacked by acid if it is not either chemically pure or well amalgamated. If the sulphuric acid is not greatly diluted, the zinc cylinders are strongly attacked by continuous use, in spite of the amalgamation, by which a great loss of metal is caused; if on the other hand, the acid is much diluted, it is soon saturated, and the action of the apparatus is enfeebled.

In my investigations I use a galvanic apparatus consisting of *copper* in dilute sulphuric acid (1 part acid and 4 parts water) as positive element, and, as a negative element, *carbon* in the mixture of bichromate of potass, sulphuric acid, and water, recommended by Wöhler and Buff. (Buff uses 100 parts of water, 12 of bichromate, and 25 of sulphuric acid.) The electromotive force of this combination is $\frac{9}{10}$ths of that of a Daniell's battery.

Its advantages are as follows:—The copper is not at all attacked by the acid when the circuit is open; the resistance of the sulphuric acid, from its being so little diluted, is a minimum: the sulphuric acid is so strong that it can be used for months without becoming saturated. As, further, the mixture of chromate of potass and sulphuric acid is in-

odorous, this combination is very convenient for working with in closed spaces.

This combination is very interesting theoretically; for as copper cannot decompose dilute sulphuric acid, the copper-carbon element is an example of a powerful apparatus in which chemical action and the disengagement of electricity are quite inseparable.—Poggendorff's *Annalen*, October 5, 1860.

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## *On a New Purple and on a Blue Dye, Soluble in Alcohol.* By C. Greville Williams.

From the Lond. Chemical News, No. 46.

Chemists familiar with dyes and pigments are aware that great efforts have lately been made to form purples by the addition of a blue to the new red colors known as magenta, fuchsine, &c. A certain amount of success has been obtained by printing carmine of indigo along with magenta red upon woolen fabrics. But this process has of necessity received a very limited application, owing to the impossibility of rendering the indigo soluble in the same menstruum as the magenta. In fact there is no blue dye or pigment soluble in alcohol known to technical chemists. Such a substance, which has been for some time vainly sought, I have at last succeeded in obtaining in large quantities from cinchonine, or rather from the chinoline which is procured by distilling the former alkaloid with caustic soda or potash. The process is, in its main features, the same as that by which I demonstrated a specific difference to exist between the chinoline from coal tar and that obtained by the process just alluded to.* I have however greatly improved the process, so as to reduce its cost to a minimum, and bring it within the reach of commercial enterprise. Cinchonine being a waste product, has in some quinine manufactories accumulated to the extent of tons, and so long as its price does not exceed 8*s.* or 10*s.* per ℔ it can with profit be employed in producing blue and purple dyes.

The quantity of crude chinoline yielded is much greater than is generally supposed, and moreover the amount of dye procurable is very great. This arises from the fact that in addition to chinoline, amyle enters into the compound, and we thus take advantage of its high atomic weight.† It might be urged that iodide of amyle is far too expensive a reagent to be employed with success in any commercial operation. To this it may be answered that fusel oil is procurable for 1*s.* 6*d.* per gallon, and iodine can now be purchased in quantity for 8*s.* and phosphorus for 2*s.* 6*d.* or 3*s.* per pound. If, therefore, a plan could be devised by which the iodine might be recovered, the entire process would acquire a practical character. Now the recovery of the iodine is easy if we follow the second method of preparation given below; moreover the sulphate and chloride of amyle will probably ere long be substituted for the comparatively costly iodine.

In order to procure the blue color, one part by weight of chinoline

* On Isomeric Alkaloids, Chemical News, vol. i. p. 15.

† $C_{10}H_{11} = 71$.

is to be boiled for ten minutes with one and a half parts of iodide of amyle. The mixture from being straw-colored becomes deep reddish brown, and solidifies on cooling to a mass of crystals. This product of the reaction is to be boiled for ten minutes with about six parts of water, and, when dissolved, filtered through paper. The filtered liquid is to be gently boiled in an enamelled iron pan over a small fire, and excess of ammonia gradually added. The ebullition may be prolonged with advantage for one hour, the evaporation of the liquid being compensated for by the gradual addition of weak solution of ammonia. The latter may be prepared by the admixture of equal volumes of ammonia of the density 0·880 and distilled water. The hour having elapsed the whole is allowed to cool, when the color will almost entirely have precipitated, leaving the supernatant liquid nearly colorless. On pouring the fluid away (preferably through a filter, in order to retain floating particles of color), the dish will be found to contain resinous looking masses which dissolve readily in alcohol, yielding a rich purplish-blue solution which may be filtered and kept for use.

The color prepared as above is, as has been said, of a purplish tint, but, if a purer blue be required the following modification is to be resorted to. The filtered aqueous solution of hydriodate of amyle-chinoline, is, as before, to be brought to the boiling temperature, but instead of adding ammonia, a solution of caustic potash containing about one-fifth of its weight of solid potash is to be substituted. The addition is to be continued at intervals until three-fourths as much potash has been added as is equivalent to the iodine in the iodide of amyle used. The fluid may, after a quarter of an hour's ebullition, be filtered to separate the resinous color. The product is a gorgeous blue with scarcely any shade of red. On adding the other fourth of potash to the filtrate while gently boiling, a black mass will be precipitated containing all the red, which otherwise would have been mixed with the blue. This mass dissolves readily in alcohol, yielding a rich purple solution, containing, however, an excess of red. The alcoholic solution on filtration leaves on the filter a dark mass soluble in benzole, and as sometimes prepared, affording a brilliant emerald green solution of great beauty. It is not always easy to obtain this green color. I have never on any occasion, however, seen a failure in preparing the blue or purple.

With regard to the economy of the process, the following is a near approximation to the produce in my later experiments. Cinchonine, distilled with excess of caustic soda, affords 65 per cent. of crude chinoline, containing in addition to that base lepidine, cryptidine, and at least two more as yet unknown homologues of chinoline, besides pyrrol and a number of bases isomeric with the pyridine series. The water that comes over in the distillation contains ammonia, and the more soluble of the latter class. All the distillate which on rectification distils above 390° or 408° Fahr. up to the highest range of the mercurial thermometer, is suitable for preparing the color.

One part of the mixture of bases above alluded to, and one and a

half parts of iodide of amyle, yield 23 parts of blue dye containing four per cent. of solid coloring matter. One volume of magenta pink, of the ordinary strength found in commerce, and two volumes of the chinoline blue, form a fine purple inclining to the blue shade. The proportion of magenta may, in many cases, be increased with advantage. The color on wool or silk stands soap well.

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To the Editor of the Journal of the Franklin Institute.

New York, Wednesday, April 17th, 1861.

Sir:—Having observed in a late number of the *Journal* an item in relation to the speed of vessels, I thought the enclosed might prove acceptable. They can be relied upon as correct.

I am, very respectfully, your obedient servant.

Edward Brandt.

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*Remarkable Speed.*

Steamship Persia.—This vessel sailed from Liverpool at noon March 30th, and from Queenstown on the evening of the 31st, arriving in New York April 9th, making the shortest passage across the Atlantic Ocean on record. The subjoined is a copy of her log:—

| Date. | Winds. | Course. | Distances. | Latitude. | Longitude. |
|---|---|---|---|---|---|
| March 30, | — | — | — | — | — |
| " 31, | N. E. | Various. | 240 | — | — |
| April 1, | Easterly, | W. N. W. | 172 | 51·13 | 14·12 |
| " 2, | — | — | 313 | 50·38 | 22·10 |
| " 3, | S. E. | W. by N. | 329 | 49·01 | 30·31 |
| " 4, | E. N. E. | — | 334 | 47·50 | 38·24 |
| " 5, | N. E. | W. by N. | 338 | 45·19 | 45·57 |
| " 6, | N. N. E. | — | 350 | 43·43 | 53·48 |
| " 7, | N. by E. | W. ½ N. | 331 | 42·27 | 61·20 |
| " 8, | North, | — | 326 | 40·50 | 68·04 |
| " 9, | " | — | 292 | — | — |

*Remarks.*—March 30.—11·30 A. M. received mails; 12 M. left Liverpool; 1·05 P. M. discharged pilot.

March 31.—Moderate and fine; 9·30 A. M. passed Roches' Point; 9·40, Queenstown; 4·05 P. M. received mails; 4·43 P. M. left Queenstown.

April 1.—Moderate and clear; 8·30 P. M. passed Steamship *Niagara*, bound east.

April 2.—Light winds and fine weather.

April 3.—Moderate, cloudy weather.

April 4.—Moderate, fine, clear weather.

April 5.—Fresh breeze, thick fog.

April 6.—Strong gale, high sea.

April 7.—Fresh gale, snow squalls.

April 8.—Moderate breeze.

April 9.—Strong breeze; 5·47 A. M. received pilot; 6·50 A. M. at Sandy Hook; 7·30 A. M. Staten Island; 8·10 A. M. New York.

Frigate Isis.—A remarkable instance of fast sailing has been recorded of this vessel, which returned into the harbor of Brest on the 16th of November last, after two incredibly rapid voyages. She left that port for Papahiti on the 19th of April, 1860, and reached her destination on the 4th of August, making the run in 107 days. Starting again on the 19th of the same month, she arrived at Brest after a voyage of 89 days, without having seen land, or putting into any harbor; thus going 10,000 leagues (more than the distance around the world), in the space of 196 days, and having been only six months and twenty-eight days at sea from her first departure. This prodigious rapidity exceeds the rate of sailing of some of the fleetest ships, as for instance, that of the *Sovereign of the Seas*, mentioned by Lieutenant Maury, U. S. N., as unique for her sailing powers, and also the voyage round the world of the *Swordfish*, performed in ten months and ten days, and equally cited by him as a remarkable trial of speed. The frigate *Isis* was equally fortunate in the healthy state of her crew and passengers, not a single case of illness or death having occurred during the entire voyage.

Clipper Bark Dawn.—The shortest passage ever made from Buenos Ayres to New York (or any other American port), was accomplished in the summer of 1860 by this bark. It was made in 36 days, from May 5th to June 12th, and as the distance is 6500 miles, it will be seen she averaged over $180\frac{1}{2}$ miles per day. Her previous passage was made in 39 days from the same port. The *Dawn* was built in New York in 1857 by Thomas Collyer, Esq., and under the command of Captain Chase, all her voyages on an average are without a parallel.

Clipper Ship Andrew Jackson.—This renowned ship arrived in the port of New York on the morning of the 20th of November last from Liverpool in 15 days passage, with a full cargo. She also made the voyage to Liverpool, laden with grain, in 15 days, and on the voyage out and home was only 30 days at sea, including 2 days of very calm weather. During this time she sailed over 6500 miles, thus averaging nearly 220 miles per day throughout—a rate of speed rarely if ever equalled, continuously, in a sailing vessel before or since, The *Andrew Jackson* was built by Messrs. C. H. Mallory & Co., of Mystic, Conn.

Bark Pallas.—This bark, commanded by Captain Biddle, from New York, February 21st last, arrived at Balize, Honduras, after the extraordinary run of eleven days. The *Pallas* was built, and is at present owned in New York. E. B.

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Translated for the Journal of the Franklin Institute.

## *A New Lubric and Varnish.—Heveone.*

At a recent meeting of the Academy of Sciences at Paris, M. Matthieu, a maker of surgical instruments, presented a vegetable fat, at the same time viscous and elastic, to which he had given the name of

*Heveone*, for the purpose of recalling at the same time, first, that its principal element is the essence of caoutchouc, or caoutchouc highly purified, prepared from *Hevæa Guyanensis;* second, that it is prepared at a very high temperature.

This new preparation possesses very remarkable properties, and will be of very great service to many branches of industry. It adheres considerably to the surfaces to which it is applied; does not oxidize under the influence of atmospheric agents; and preserves from rust, instruments of iron, steel, copper, or any other polished metal, even when spread over them in an infinitely thin coating. Surgical and domestic instruments, tools and machinery, hunting and other weapons, may be kept perfectly clean and bright.

The lubricating properties of *Heveone* are still more extraordinary; applied to stop-cocks, pistons, valves, pivots, axles, locks, hinges, &c., it makes them play the more easily, inasmuch as it never dries, does not lose its viscosity, does not oxidize, nor combine with the metals.

*Heveone*, besides, as a coating impermeable to water, will do much to keep clean and in good order, leather, and objects formed of leather, such as shoes, harness, belts, &c.; it will protect them both from damp and from too great dryness; it makes them very pliable, and renders them imperishable; its salutary effects will extend even to wood, pedestals, panels, wainscoating, &c. We will relate one more very precious property of *Heveone.* In fire-arms coated interiorly with it, there no longer forms any adhesive dust in firing; they will be much more easily cleaned, and when fired frequently in succession, the aim will remain more certain and the range greater.—*Cosmos.*

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Translated for the Journal of the Franklin Institute.

## *A new Stereoscope without Lenses.*

In the *Nuovo Lincei*, M. Volpicelli describes a new stereoscope presented by him in April, 1854. This very simple stereoscope without mirrors or lenses, consists of a rectangular horizontal box, whose proportions are as follows: height 11 centim. (4·5 ins.); depth 20 centim. (8 ins.); length 62 centim. (24·8 ins.) The two stereoscopic pictures are placed against the back of the box; in the front of the box two holes are bored opposite the middle of the pictures. Two diaphragms made of plates of blackened wood or card-board, of the height of the pictures, are made to rotate around vertical axes corresponding to the front edges; and are so adjusted that they allow the right eye to see only the left picture, and the left eye the right picture. It follows that the rays by which the pictures are seen cross each other within a certain space in the middle of the box, and in this space, after a little effort, the eyes see the object in relief.

If after the relief is seen the diaphragms are turned around their axes, so as to rest against the sides of the box, and no longer intercept the view—the eyes still continuing to view the picture in relief—a very interesting physiological phenomenon will be seen. There will be seen three pictures—one in the middle of the instrument, in relief,

the others alongside, and by no effort of will can the middle picture be made to disappear.

If the pictures be of complementary colors, they will be seen of their own colors, and the relief will be white.

Those who are not accustomed to observation of optical phenomena will require some attention to see the relief at first, but it will generally be found by looking attentively at about the middle of the box. When once seen it may be recovered without any difficulty.

*Cosmos,* September, 1860.

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Translated for the Journal of the Franklin Institute.

## *Preparation of Oxygen from Sulphuric Acid.*

The acid of the chambers, or still better that concentrated to 61°, will serve excellently for the very easy preparation of oxygen, since at a feeble red heat it is completely transformed into a mixture of water, sulphurous acid, and water.

A retort of 5 quarts filled with platinum foil, or still better, a platina worm filled with platina sponge is brought to a red-heat. A small stream of the sulphuric acid passing through an S tube and running steadily is introduced; the gases which are produced pass first through a refrigerator to separate the water, and then through a peculiar washer. There escapes oxygen gas pure and without smell, and a concentrated solution of sulphurous acid.—*Cosmos,* November, 1860.

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## *Artificial Leather.*

From the London Builder, No. 932.

We lately took occasion to allude to endeavors to realize an idea suggested in the *Builder* on this subject; and we now extract the following remarks, in a condensed form, as to a farther step in progress, from the *Suffolk Chronicle:*—"To Ipswich belongs the honor of an invention to gather up vast heaps of rubbish in the shape of leather cuttings, parings, and shavings; and by a peculiar process, partly chemical and partly mechanical, to reduce them to a pulpy mass, and mould them to any desired form for useful and ornamental purposes. A factory is now erected, and a company formed, bearing the name of the 'Patent Plastique Leather Company.' The goods manufactured are more durable, and 20 to 30 per cent. cheaper than all other leather goods. We have made inquiry into this new process, and find the leather may be made as pliant as india rubber, or as hard as board, and becomes adapted to an endless variety of uses, as bands for machinery, buckets for pumps (having all the suction of leather, with ten-fold durability), and rubber for pencil marks. It is eminently adapted for all kinds of architectural ornamentation, in-door or out, and is an excellent material for picture frames, plain or gilded, not being liable to cast or break. It can be made of any color, matching the grain of all dark wood so accurately that even a skilful workman would mistake it for carving. This most truly useful invention, we have no doubt, under the hand of its originator, Mr. R. Seager, will ere long, take its rank among our staple manufactures.

# AMERICAN PATENTS.

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| —— Burner Regulators, | A. H. Wood, | Boston, | Mass. | 19 |
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| ——,———— and Extinguish. | N. S. Manross, | Forrestville, | Conn. | 5 |
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| ——— | M. L. Roberts, | Mt. Union, | Ohio, | 12 |
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| Ploughs, | J. K. Gingrich, | N. Annville, | Penna. | 19 |
| ——— | D. H. Maloy, | Temperance, | Ga. | 26 |
| ——— | J. M. Rodman, | South Union, | Ky. | 26 |
| ——— | H. D. Rogers, | Grafton, | Ohio, | 12 |

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| ——— . | W. F. Shedd, . | Ripley, | Ohio, | 26 |
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| Pottery,—Machines for Moulding | Wm. Linton, . | Baltimore, | Md. | 12 |
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| ———,—Cotton . | A. Z. McBride, . | Hannahatchee, | Ga. | 5 |
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| ———,—Swaging | W. H. Beach, . | Chicago, | Ill. | 5 |
| Shoemakers Clamp, . | Peter Hanes, | Edina, | Mo. | 26 |
| Shutters,—Rolling Iron | J. S. Cochrane, . | City of | N. Y. | 5 |
| Silk and other Threads,—Sorting | Goodrich Holland, . | Willimantic, | Conn. | 5 |
| ——— | " | " | " | 19 |
| —— Thread,—Sorting . | Atwood & Leigh, . | Mansfield Cent. | " | 19 |

| | | | | |
|---|---|---|---|---|
| Skate Fastenings, . | P. J. Clark, . | W. Meriden, | Conn. | 5 |
| Skirts,—Tape for Spring . | T. D. Hoxsey, . | Paterson, | N. J. | 12 |
| Sleeve Fasteners, . | Dutee Wilcox, . | Providence, | R. I. | 12 |
| Smoking Tubes, . | W. A. Ludden, . | Brooklyn, | N. Y. | 19 |
| Sowing Machines, | P. D. Cummings, | Portland, | Me. | 26 |
| Spoons,—Manufacture of | G. I. Mix, . | Wallingford, | Conn. | 26 |
| Springs,—Carriage | E. Roughton, . | Frostburgh, | Md. | 26 |
| ———,—Metallic . | G. W. McMinn, . | Covington, | Ky. | 19 |
| Stave Machine, . | E. and B. Holmes, | Buffalo, | N. Y. | 8 |
| Staves,—Chiming and Jointing | Bowker & Bensel, . | City of | " | 12 |
| ———,—Mak. Wooden Vessels | W. H. Smoote, . | Pr.William co, | Va. | 19 |
| Steam Boilers, . | Henry Hoffman, . | City of | N. Y. | 26 |
| ——— Carriages,—chang. Speed | John Griffin, . | Louisville, | Ky. | 19 |
| ——— Engines, . | Peter Murray, . | Detroit, | Mich. | 19 |
| ——————— . | S. H. Whitmore, | Cincinnati, | Ohio, | 19 |
| ——————,—Packing for | J. H. Gould, . | Philadelphia, | Penna. | 19 |
| ——————,—condensed st. | Wm. A. Lighthall, | City of | N. Y. | 26 |
| ——————,—Register for | P. L. Weimer, . | Lebanon, | Penna. | 26 |
| ——————,—Condenser for | Cragg & Archbold, | Baltimore, | Md. | 19 |
| ——— Generators, . | F. E. Schmidt, . | City of | N. Y. | 5 |
| Stereoscopes, . | S. D. Goodale, . | Cincinnati, | Ohio, | 5 |
| Stereoscopic Pictures, . | Coleman Sellers, . | Philadelphia, | Penna. | 5 |
| Stoves, . | S. T. Savage, . | Albany, | N. Y. | 19 |
| ——— and Ranges,—Cooking | James Spear, . | Philadelphia, | Penna. | 19 |
| Stove Covers,—Lifter for | B. R Hathaway, | Mormon Island, | Cal. | 26 |
| Straw Cutters, . | Ira Reynolds, . | Bellefontaine, | Ohio, | 5 |
| ——————— . | O. C. Taylor, . | E. Burlington, | Penna. | 12 |
| Stuffing Boxes,—Packing for | Ross and Thos. Winans, | Baltimore, | Md. | 5 |
| Stump Machine, . | D. W. Henderson, | Deerfield, | Penna. | 12 |
| Switches,—Railroad . | J. M. Brahn, . | Red Bank, | N. J. | 19 |
| Syringes,—Enema | G. W. Hubbard, | City of | N. Y. | 5 |
| Table,—Extension . | T. Q. Hall, . | Fairfield, | Iowa, | 5 |
| ———,—Folding . | Josee Johnson, . | City of | N. Y. | 5 |
| Thread,—Machines for Winding | E. M. Stevens, . | Boston, | Mass. | 5 |
| Tile Machines, . | Tiffany & Ingraham, | Palmyra, | Mich. | 26 |
| Tire,—Upsetting . | Salmon & Bliss, . | Placerville, | Cal. | 19 |
| ——————— . | C. M. Wilkins, . | W. Andover, | Ohio, | 12 |
| Toy Horse, . | J. A. Crandall, . | City of | N. Y. | 26 |
| Traps,—Animal . | W. T. Williams, | " | " | 19 |
| Troughs,—Cutting Wooden | Arcalous Wyckoff, . | Elmira, | " | 19 |
| Type,—Machines for Cutting | J. J. C. Smith, . | Philadelphia, | Penna. | 5 |
| Valves of Steam Engines, | Wm. Smith, . | Philadelphia, | Penna. | 5 |
| Vapor Burners for Heating, &c., | R. R. Lewis, . | City of | N. Y. | 19 |
| Varnish,—Manufacture of | Frederick Walton, . | Manchester, | Engl'd, | 5 |
| Vegetable Cutter, . | M. R. Hubbell, . | Wolcott, | Vt. | 19 |
| ——— Fibre,—Treating | Gelston Sanford, . | City of | N. Y. | 19 |
| Violins, &c.,—Tuning Pegs for | John Albert, . | Philadelphia, | Penna. | 5 |
| Washing Machine, . | H. C. Alford, . | Minooke, | Ill. | 12 |
| ——————— | C. Carter, . | Franklin Cent. | Iowa, | 26 |
| ——————— . | R J. Converse, . | Coventry, | N. Y. | 26 |
| Waste Matter,—Receptacle for | George Herdtfelder, | City of | " | 19 |
| Watchmakers Lathes, . | Chas. Tribby, . | Winchester, | Va. | 5 |
| Water Elevators, . | P. Anderson, . | Norwich, | N. Y. | 12 |
| ——————— . | C. H. Dunbrack, . | Jacksonville, | Ill. | 12 |
| ——— Wheels, . | Ebenezer Tuttle, | Canaan, | Me. | 12 |
| Weighing Apparatus, . | A. B. Davis, . | Philadelphia, | Penna. | 26 |
| Well, Cisterns, &c.,—Walling | Frederick Wilford, | Eagle, | Wis. | 19 |
| Wheels,—Joints of Felloes in | F. M. Gibson, . | Chelsea, | Mass. | 5 |
| ———,—Spokes and Felloes in | D. A. Johnson, . | " | " | 19 |
| Whips, . | J. R. Cannon, . | New Albany, | Ind. | 12 |
| Window Sashes,—Hanging, &c., | H. T. Stanard, . | Wayne, | Mich. | 12 |

| | | | | |
|---|---|---|---|---|
| Wire,—Harden'g and Temper'g | Ichabod Washburn, . | Worcester, | Mass. | 5 |
| Wrench, . | Wm. Mason, . | Warren, | " | 26 |

ADDITIONAL IMPROVEMENTS.

| | | | | |
|---|---|---|---|---|
| Coupling for Railroad Cars, | A. H. Rowand, . | Allegheny, | Penna. | 26 |
| Gas Meters, . | Willson & Fox, | Reading, | " | 26 |
| Railroad Cars,—Couch Seats for | John Hartman, Jr., . | Philadelphia, | " | 26 |
| Seeding Machines, | F. Chamberlin, . | Berlin, | Wis. | 26 |

RE-ISSUES.

| | | | | |
|---|---|---|---|---|
| Cars from one track to another, | Wm. Wharton, Jr., . | Philadelphia, | Penna. | 19 |
| Clover Separators, | Christian Reif, . | Hartleton, | " | 5 |
| Flouring Mills, . | D. S. Wagener, . | Penn Yan, | N. Y. | 5 |
| Gin'g Cotton and Bur'g Wool, | S. R. Parkhurst, | W. Bloomfield, | N. J. | 12 |
| Knife and Fork Cleaner, . | Sewall Brackett, . | Fall River, | Mass. | 5 |
| Ploughs,—Mole . | M. A. Howell, Jr., | Ottawa, | Ill. | 19 |
| Pumps.—Portable . | W. T. Vose, . | Newtonville, | Mass. | 26 |
| Sewing Machine Cases, | Ross & Marshall, | City of | N. Y. | 26 |
| Ships Winches, . | P. H. Jackson, . | " | " | 19 |
| Stoves,—Registers for | S. H. Ransom & Co., | Albany, | " | 19 |
| Timekeepers by Air,—Winding | C. B. Hoard, . | Watertown, | " | 19 |
| Willow Peeler, . | J. M. Wood, . | Seneca, | " | 26 |
| Window Curtain Fixture, | R. B. Burchell, . | Brooklyn, | " | 26 |

DESIGNS.

| | | | | |
|---|---|---|---|---|
| Carpet, . | R. Allan, . | Camden, | N. Y. | 5 |
| Carpets (2 cases), . | E. J. Ney, . | Lowell, | Mass. | 5 |
| ——— 16 " . | H. G. Thompson, | City of | N. Y. | 12 |
| Stove, . | J. D. Warren and other, | Stamford, | Conn. | 5 |
| ———,—Cooking . | John Long, . | Massillon, | Ohio, | 19 |
| Trade Mark, . | Sampson Hainemann, | City of | N. Y. | 26 |

## FRANKLIN INSTITUTE.

*Proceedings of the Stated Monthly Meeting, April* 18, 1861.

John C. Cresson, President, in the chair.

John Agnew, Vice President.

The minutes of the last meeting were read and approved.

Letters were read from the Royal Geographical Society, London, and the Literary and Philosophical Society of Liverpool, England.

Donations to the Library were presented by the Royal Astronomical Society, the Royal Geographical Society, the Institution of Civil Engineers, the Chemical Society, the Institute of Actuaries, and the Commissioners of Patents, London; the National Observatory and John Lenthall, Esq., Washington City, D. C.; Junius S. Smith, Esq., Buffalo, New York; the Haytian Bureau of Emigration, Boston, Massachusetts; William Wrightson, Esq., Cincinnati, Ohio; H. G. Leisenring, Pennsylvania Legislature, Harrisburgh, Pennsylvania; and Charles E. Smith, Esq., W. Parker Foulke, Esq., James C. Kempton, Esq., H. P. M. Birkinbine, Esq., Wm. A. Rolin, Esq., Prof. John F. Frazer, Prof. John C. Cresson, and the Philadelphia and Reading Railroad Company, Philadelphia.

Donations to the Cabinet.—J. J. Thibault, Esq., presented specimens of gold, silver, and copper ore from Arizona Territory.

The Periodicals received in exchange for the Journal of the Institute, were laid on the table.

The Treasurer's statement of the receipts and payments for the month of March was read.

The Board of Managers and Standing Committees reported their minutes.

Candidates for membership in the Institute (6) were proposed, and the candidates proposed at the last meeting (5) duly elected.

The Actuary reported that the Standing Committee on Meetings have organized by electing Washington Jones, Esq., Chairman for the ensuing year, and appointing the Monday evening previous to the 3d Thursday of each month for holding their stated meetings.

Mr. Meyers, of Messrs. Mitchell, Vance & Co., New York, exhibited a neat sample of an apparatus for lighting gas by electricity. The machine consists of a small glass disc, which revolves between two pads of leather, and gives the generated electricity to points, which are in communication with a brass rod about 12 inches long terminating in a ball. An insulated handle is attached to the lower part of the instrument. A piece of wire, attached to a sheath which slips over the burner, is so adjusted that a spark given to it from the ball of the gas lighter passes through the jet of flowing gas and instantly inflames it.

"Fox's Self-adjusting Drill Chuck" was laid upon the table for the inspection of the members. It consists of a globular piece contained in a chamber formed within another piece which is attached to the spindle of the Drilling Machine. The globular piece has a hole passing through it for the reception of the drill shank, and is so made as to expand when the drill shank is forced into it from the pressure exerted by the feed screw. This pressure is not so great when the drill is just entering the material as to jam the globular piece, and it consequently moves in its socket until the point of the drill is in line with the axis of the spindle, when the greater pressure required to force the increased cutting edge of the drill into the material forces the taper shank into the globular piece, and causes it to expand and become fixed in position.

## BIBLIOGRAPHICAL NOTICE.

*Annual Report of the Chief Engineer of the Water Department of the City of Philadelphia. Presented to Councils Feb.* 21*st*, 1861.

We extract from this document, which will be found very interesting to our immediate citizens, the following information, which is of general interest, as showing the efficiency of the works and fixing data for calculations for other works of similar character.

Philadelphia is supplied with water by four water-works of different character and locations, but under the charge of the same committee of Councils and Chief Engineer. The amount of work done by

each of these works, with the character of the motors used is given in the following table, which is condensed from those in the Report.

| Works. | Average quantity in gallons per day for each month. | | | Cost of raising 1,000,000 galls. 1 foot high. | Average duty of engine. |
|---|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | | |
| 1 Fairmount, | 12,446,775 (July.) | 7,731,735 (Dec.) | 9,867,378 | 11·7 cts. | [100 lbs. anthr. |
| 2 Schuylkill, | 10,812,817 " | 4,864,850 " | 7,360,849 | 10·3 " | 32,115,800 lbs. per |
| 3 Delaware, | 3,015,148 " | 1,500,091 (Feb.) | 2,379,727 | 21· " | 20,525,800 " " |
| 4 24th Ward, | 1,070,436 " | 611,165 " | 774,112 | 14·4 " | 38,500,800 " " |

No. 1. is driven by eight breast wheels, and one Turbine (Jonval); Pumps 16 ins.
No. 2. Two reciprocating overhead beam engines, 36 ins.×6 ft.; Pumps 18 in.×6 ft.
One reciprocating bell crank engine, 36 in.×6 ft.; Pump 21 ins.×6 ft.
One Cornish overhead-beam engine, 60 in.×10 ft.; Pumps 30 in.×10 ft.
No. 3. One horizontal high-pressure engine 30 in.×6 ft.; Pump 18 in.×6 ft.
One beam, condensing engine, 36 in.×6 ft; Pump 18 in. ×6 ft.
No. 4. Two Cornish Bull-engines, 50 in.×8 ft; Pumps 17 in. ×8 ft.

The total supply during the year was, from

| | | |
|---|---|---|
| Fairmount, | 3,612,987,017 | gallons. |
| Schuylkill, | 2,696,960,210 | " |
| Delaware, | 872,144,980 | " |
| 24th Ward, | 283,646,070 | " |
| | 7,465,738,277 | " |

The cost of raising the water has been less this year than it was last, and very materially less than that of 1858. Yet the average duty of the engines, which is given as 321,158 lbs. raised 1 ft. high per lb of anthracite, shows that much is yet to be done in the improvement of the steam works while the water-wheels at Fairmount are now far behind our wants, and will be soon replaced.

The report terminates with an account of the experiments made to determine the best form of wheel to be used in the extension of the Fairmount works. We do not propose to go into the details of these experiments, which can scarcely be usefully condensed, but confine ourselves to stating as the general result, that the contract has been given to M. Geyelin of this city, who is the agent for the Jonval Turbine. The subjoined note will give the reasons for this decision.

Department for Supplying the City with Water.
Philadelphia, April 5th, 1861.

Emile Geyelin, Esq.—Dear Sir:—The following are the reasons that influenced the Department in awarding you the contract for furnishing the Jonval Turbine Water Wheels for working the New Pumps at the Fairmount Water Works:—

First: The fact that your model gave the best average per centage over all others brought into competition.

Second: The durability and continued satisfactory operation of your Jonval Turbine erected at Fairmount in 1851.

Third: The general and highly competent evidence brought before the Committee of your ability as a constructor of Turbine Wheels.

Fourth: The fact of your estimate of cost being considerably lower than that of any other party. Yours, respectfully,

Henry P. M. Birkinbine, *Chief Engineer.*

# METEOROLOGY.

For the Journal of the Franklin Institute.

*The Meteorology of Philadelphia.* By James A. Kirkpatrick, A.M.

Thermometrical Observations.—The following tables of results have been deduced from observations extending over a period of nine and a half years. The position occupied is in latitude 39° 57′ 28″ N., and longitude 75° 10′ 28″ W. from Greenwich, and fifty feet above high water in the Delaware River. The instruments are protected from radiated and reflected heat, as well as from the direct influence of the sun's rays. The observations were made at 7 o'clock in the morning, 2 in the afternoon, and 9 in the evening.

The warmest days of the year, according to the observations made during this period of time, are the 29th, 30th, and 28th days of June, having the following mean temperatures:—

| | | |
|---|---|---|
| June 29th, | average mean temperature, | 82·0° |
| " 30th, | " " | 81·6 |
| " 28th, | " " | 81·3 |

The coldest days, taking the average temperature for the last ten years, are January 23d, February 3d, and January 9th, with the following means:—

| | | |
|---|---|---|
| January 23d, | average mean temperature, | 24·2° |
| February 3d, | " " | 27·2 |
| January 9th, | " " | 27·4 |

The average temperature of each of the other days of the year, is above 28°.

The warmest day during the whole period of observation was the 21st of July, 1854, of which the mean temperature was 91·3°. The highest degree was reached on the same day, when the thermometer indicated 100·5°.

The coldest day during the same time was the 9th of January, 1856, of which the mean temperature was one degree below zero. The lowest point indicated by the register thermometer was 5½° below zero, on the 23d of January, 1857.

The average temperature of the hours of observation, for every month and season of the year, for ten years, is shown in Table I. The temperature at 7 A. M. is found to be about 4·6 degrees below the mean; at 2 P. M. it is 5·7 degrees above; and at 9 P. M., 1·1 degrees below the mean. The difference of temperature between 7 A.M. and 2 P. M., is less in Winter and greater in Spring than in the other seasons; the average difference in the former season being 8·2°, and in the latter, 11·6°. The average difference of temperature between 2 and 9 P. M., is 4·6° during the Winter months; 7·6 in Spring; and 7·4° in Summer and Autumn.

TABLE I.—*Average mean temperature of the different hours of observation, for the months, seasons, and year; as deduced from observations continued for ten years, at Philadelphia.*

| Months. | 7 A. M. | 2 P. M. | 9 P. M. | Mean. |
|---|---|---|---|---|
| | ° | ° | ° | ° |
| January, . . | 27·24 | 35·18 | 30·80 | 31·07 |
| February, . | 28·70 | 37·92 | 32 93 | 33·18 |
| March, . . | 35·72 | 47 34 | 40·62 | 41·23 |
| April, . . | 45·58 | 57·43 | 49·39 | 50·80 |
| May, . . | 58·47 | 69·79 | 61·61 | 63·29 |
| June, . . | 69·25 | 79·29 | 72 07 | 73·54 |
| July, . . | 74·10 | 83·93 | 76·78 | 78 27 |
| August, . | 70·29 | 80·74 | 73·37 | 74·80 |
| September, . | 62·58 | 74·91 | 66·63 | 68·04 |
| October, . | 50·97 | 63·03 | 55·17 | 56·39 |
| November, . | 41 23 | 50 53 | 44·45 | 45·40 |
| December, . | 31·65 | 38·91 | 34·44 | 35 00 |
| Annual Means, . | 49·69 | 59·98 | 53·19 | 54·29 |
| Winter, . | 29·29 | 37·46 | 32·83 | 33·19 |
| Spring, . . | 46 59 | 58·19 | 50·54 | 51·77 |
| Summer, . | 71·20 | 81·43 | 74·01 | 75·55 |
| Autumn, . . | 51·59 | 62·82 | 55·42 | 56·61 |

The mean temperature of each month, shown in Table II, is ascertained by taking the average of the mean temperatures of each day; the latter being obtained by averaging the three observations of the day. The mean temperature of the season is ascertained by combining the means of the three months constituting the season; and the mean temperature for the year is obtained by taking the average of the means for each month of the year.

TABLE II.—*Mean temperature of the months, years, and seasons, at Philadelphia, from July,* 1851, *until December,* 1860, *inclusive.*

| Months. | 1851. | 1852. | 1853. | 1854. | 1855. | 1856. | 1857. | 1858. | 1859. | 1860. | Mean. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° |
| January, | | 26·48 | 33·21 | 32·91 | 34·33 | 23·59 | 20 92 | 40·81 | 34·00 | 33·41 | 31·07 |
| February, | | 33·79 | 37·80 | 34·85 | 26·67 | 26·73 | 39·94 | 30·11 | 36·43 | 32·33 | 33·18 |
| March, | | 41·19 | 42 81 | 43·16 | 38 80 | 33·35 | 38·23 | 40·67 | 48·12 | 44·73 | 41·23 |
| April, | | 47·29 | 53·44 | 51·39 | 52 90 | 54·46 | 45·44 | 52·52 | 50·28 | 49·48 | 50·80 |
| May, | | 64·31 | 64·29 | 65·33 | 63·76 | 62·66 | 61·22 | 59·31 | 64 65 | 64·09 | 63·29 |
| June, | | 72 87 | 75·29 | 73·28 | 71·87 | 77 22 | 71·20 | 77·54 | 70·85 | 71·71 | 73·54 |
| July, | 78·60 | 78 04 | 76·60 | 80·30 | 79·71 | 80·06 | 77·26 | 79·22 | 76·00 | 76·91 | 78·27 |
| August, | 74·18 | 74·11 | 75 71 | 76 65 | 75 02 | 72·15 | 75·26 | 74·96 | 74·53 | 75·43 | 74·80 |
| September, | 68·95 | 67·33 | 68·47 | 70 17 | 70·20 | 66·16 | 69·17 | 67·92 | 66·18 | 65·82 | 68·04 |
| October, | 58·55 | 58·85 | 53·93 | 59·15 | 55·20 | 53 42 | 56 19 | 59·49 | 52·32 | 56·83 | 56 39 |
| November, | 43 55 | 42·53 | 48·43 | 46·12 | 48 28 | 43·12 | 45·86 | 42·22 | 47·49 | 46·39 | 45·40 |
| December, | 30·19 | 41·73 | 35·26 | 31·26 | 37·50 | 30 11 | 41·03 | 37·65 | 33 00 | 32·26 | 35·00 |
| Annual means, | | 54·04 | 55 44 | 55·38 | 54·53 | 51·92 | 53·48 | 55·20 | 54·49 | 54·12 | 54·29 |
| Winter, | | 30·15 | 37·58 | 34·34 | 30·75 | 29·28 | 30·32 | 37·31 | 36·03 | 32 91 | 33·19 |
| Spring, | | 50·93 | 53·51 | 53·29 | 51·82 | 50·16 | 48 29 | 50·83 | 54·35 | 52·77 | 51 77 |
| Summer, | | 75·03 | 75·87 | 76·74 | 75·53 | 76·48 | 74·57 | 77·24 | 73 79 | 74·68 | 75 55 |
| Autumn, | 57·02 | 56 24 | 56·94 | 58·48 | 57·87 | 54·28 | 57·07 | 56·54 | 55·33 | 56·35 | 56 61 |

It will be seen by this table that the warmest year was 1853, but it was only 1·15° above the average temperature for the whole time. The coldest year was 1856, which was 2·37° below the average. The whole range of annual temperatures, or the difference between the warmest and coldest year, was only $3\frac{1}{2}$°. The mean annual temperature of Philadelphia for the nine years from 1852 till 1860, inclusive, is 54·29°.

By the *mean daily oscillation* given in the third table, is meant the average of the differences between the highest and lowest degrees of temperature of each day, as observed by means of the register or maxima and minima thermometer. The difference between the highest and lowest degrees for one day gives the oscillation for that day; the sum of the oscillations for all the days of the month divided by the number of days in the month, gives the mean daily oscillation for the month, as given in the table. The mean daily oscillation for the different seasons is found by taking the average of the oscillations of the three months composing the season; and the mean daily oscillation for the year is ascertained by taking the average of the oscillation for the twelve months composing the year.

It will be seen by the table, that the changes of temperature during the day are about the same in the Spring and Autumn, but that they are nearly four degrees less in Winter than in Summer. The average daily oscillation for the whole time of observation, is 15°.

TABLE III.—*Mean daily oscillation of temperature for every month, season, and year, at Philadelphia, from July,* 1851, *till December,* 1860, *inclusive.*

| Months. | 1851. | 1852. | 1853. | 1854. | 1855. | 1856. | 1857. | 1858. | 1859. | 1860. | Mean. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° |
| January, | | 11·1 | 12·9 | 10·2 | 9·4 | 11 0 | 10·3 | 14·0 | 13·0 | 14 8 | 11·9 |
| February, | | 10·9 | 12·3 | 12·7 | 10·2 | 12·7 | 15·0 | 14·4 | 13·2 | 17·8 | 13·2 |
| March, | | 13·8 | 13 7 | 12·7 | 11·9 | 12·8 | 15·0 | 17·1 | 16 9 | 18·3 | 15 2 |
| April, | | 12·5 | 18 6 | 15·7 | 17·0 | 17·6 | 15·8 | 17·3 | 15·5 | 18·9 | 16·5 |
| May, | | 16·9 | 17·3 | 16·6 | 17·7 | 13·2 | 15·8 | 14·6 | 19·7 | 17·2 | 16·6 |
| June, | | 16·0 | 17·5 | 16·4 | 12·8 | 10·8 | 14·4 | 18·3 | 18·9 | 18 9 | 16·0 |
| July, | 12·6 | 15·1 | 14·6 | 14·2 | 12·0 | 18·6 | 14·5 | 17·2 | 20·2 | 19·8 | 15·9 |
| August, | 14·5 | 13 3 | 14·8 | 14·6 | 11·5 | 20·0 | 15·3 | 16·1 | 20·5 | 18·8 | 15·9 |
| September, | 16·1 | 16 4 | 14 7 | 13·6 | 14·9 | 20·9 | 17·5 | 19·7 | 18·1 | 18·2 | 17·0 |
| October, | 16·2 | 14·4 | 15·9 | 13·1 | 13·4 | 17·0 | 15·0 | 17·3 | 18·1 | 16·1 | 15·6 |
| November, | 9 7 | 10·7 | 13·0 | 10·3 | 10·9 | 17·3 | 16·9 | 12·3 | 18·6 | 14·4 | 13·4 |
| December, | 10·5 | 11·5 | 12·2 | 10 2 | 11·7 | 12·3 | 13 4 | 11·8 | 14·2 | 12·2 | 12·0 |
| Annual means, | | 13·6 | 14·8 | 13 4 | 12·8 | 15·3 | 14·9 | 15·8 | 17·2 | 17·1 | 15 0 |
| Winter, | | 10·8 | 12·2 | 11·7 | 10 4 | 11·8 | 12·5 | 13·9 | 12·7 | 15·6 | 12·4 |
| Spring, | | 14·4 | 16·5 | 15 0 | 15·5 | 14·5 | 15·5 | 16·3 | 17·4 | 18 1 | 15·9 |
| Summer, | | 14 8 | 15·6 | 15·1 | 12·1 | 16·5 | 14·7 | 17·2 | 19·9 | 19·2 | 16·1 |
| Autumn, | 14·0 | 13 8 | 14 5 | 12·3 | 13·1 | 18·4 | 16·5 | 16·4 | 18 3 | 16·2 | 15·3 |

By the *mean daily range* given in the fourth table, is meant the change of temperature from one day to the next. It is ascertained by taking the average of the differences of temperature between the two days at the several hours of observation. Thus, if we suppose the observed temperatures to be as follows:—

| | | | |
|---|---|---|---|
| 1860, December 1st, | 7 A. M., $36\frac{1}{2}°$ | 2 P. M., $34°$ | 9 P. M., $32°$ |
| " " 2d, | " 30 | " $35\frac{1}{2}$ | " 35 |
| Differences, | $6\frac{1}{2}°$ | $1\frac{1}{2}°$ | $3°$ |

of which the average is 3·7°, which is called the mean daily range for the 2d of December. The average of all the results obtained in this way for a month, gives the mean daily range for the month; and the average of the results for the different months, gives the mean daily range for the season, or for the year, according to the months taken. From this table, it will be seen that the difference of temperature between one day and the next, is greatest in the winter months, reaching its maximum in February, and least in the summer months, arriving at its minimum in July and August. The annual means differ but eight-tenths of a degree between the highest and lowest, from 5·2° in 1858, to 6° in 1856 and 1859.

Table IV.—*Mean daily range of temperature, for every month, season, and year, at Philadelphia, from July,* 1851, *till December,* 1860, *inclusive.*

| Months. | 1851. | 1852 | 1853 | 1854. | 1855. | 1856. | 1857 | 1858. | 1859. | 1860. | Mean. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° |
| January, | | 6·4 | 5·5 | 8 6 | 6 7 | 6·5 | 7·7 | 5·9 | 8·0 | 6·5 | 6·9 |
| February, | | 6·2 | 7·2 | 8·0 | 5·8 | 8·1 | 9·2 | 6·1 | 6·3 | 8·8 | 7·3 |
| March, | | 7·0 | 6·5 | 6·5 | 5 8 | 5·3 | 6·4 | 6·0 | 6 0 | 5·4 | 6·1 |
| April, | | 4·8 | 6·3 | 7 2 | 7·1 | 6·6 | 6·0 | 7·0 | 6·3 | 7·4 | 6·5 |
| May, | | 5·1 | 6·6 | 5·1 | 5·2 | 7·0 | 4·8 | 5·5 | 5·7 | 5·2 | 5·6 |
| June, | | 4·8 | 4·7 | 4·4 | 4·2 | 4·7 | 4·2 | 4·4 | 6·1 | 4·2 | 4·6 |
| July, | 3·1 | 3·6 | 3·5 | 3·6 | 3·9 | 3·9 | 2·9 | 3·7 | 4·6 | 5·0 | 3·8 |
| August, | 3·3 | 3·7 | 4·0 | 4 6 | 3·5 | 4 1 | 3·2 | 4·4 | 3·1 | 3.8 | 3·8 |
| September, | 4·4 | 4·5 | 4·3 | 6·1 | 5·4 | 5·0 | 4·6 | 4·1 | 4·1 | 5 2 | 4·8 |
| October, | 5·0 | 5·6 | 5 9 | 4·9 | 5·8 | 7·3 | 4·3 | 5·3 | 5·9 | 5·8 | 5·6 |
| November, | 3·9 | 5·0 | 6·5 | 5 9 | 5·2 | 7·8 | 7·1 | 3·5 | 7·3 | 5·5 | 5·8 |
| December, | 4 5 | 7·1 | 6·1 | 6 5 | 6·4 | 6 3 | 5·7 | 6·3 | 8·4 | 5·0 | 6·4 |
| Annual means, | | 5·3 | 5·6 | 5 9 | 5 4 | 6·0 | 5·5 | 5·2 | 6·0 | 5·6 | 5·6 |
| Winter, | | 6·4 | 6·6 | 7·6 | 6 3 | 7·0 | 7·7 | 5·9 | 6·9 | 7·9 | 6·9 |
| Spring, | | 5·6 | 6·5 | 6 3 | 6·0 | 6·3 | 5·7 | 6·2 | 6·0 | 6·0 | 6·1 |
| Summer, | | 4·0 | 4·1 | 4·2 | 3·9 | 4·2 | 3·4 | 4·2 | 4·6 | 4·3 | 4·1 |
| Autumn, | 4·4 | 5·0 | 5·6 | 5·6 | 5·5 | 6·7 | 5·3 | 4·3 | 5·8 | 5 5 | 5·4 |

The fifth table contains the extreme monthly, annual, and quarterly range of the thermometer. The extreme monthly range of tempera-

ture is found by taking the difference between the highest and lowest degree indicated by the thermometer during each month; the quarterly range is found by subtracting, in the same manner, the lowest from the highest degree indicated by the thermometer during the quarter; and the annual range shows the difference between the maximum and minimum for each year. The last column contains the average differences for each month, season, and year.

TABLE V.—*Extreme monthly, annual, and quarterly oscillation of temperature, for every month, year, and season, together with the average oscillation for each month, &c., from July,* 1851, *till December,* 1860, *inclusive, at Philadelphia.*

| Months. | 1851. | 1852. | 1853. | 1854. | 1855. | 1856. | 1857. | 1858. | 1859. | 1860. | Mean. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° | ° |
| January, | | 52·0 | 43 0 | 46·5 | 46·0 | 47 | 43·5 | 40 | 57 | 54·5 | 47·7 |
| February, | | 48·5 | 44·5 | 45 | 47·5 | 46 | 59 | 42 | 45 | 69 | 49 6 |
| March, | | 49·0 | 53 | 53 | 48 | 45 | 54 | 61 | 50 | 48 | 51·2 |
| April, | | 37·0 | 45 | 57 | 65 | 57 | 44·5 | 51 | 47 | 52 | 50·6 |
| May, | | 41·5 | 43 | 49 | 47 | 44 5 | 44·5 | 35 | 43 | 46 | 43·7 |
| June, | | 46 | 47 | 47 | 44 | 44 | 38 | 43·5 | 54 | 41 | 44·9 |
| July, | 29·0 | 32 | 34 | 37·5 | 38 | 40 | 38 | 35·5 | 43 | 38·5 | 36·5 |
| August, | 33·5 | 30·5 | 39 | 39 | 29 | 50 | 34 | 36 | 45 5 | 40 | 37·6 |
| September, | 52·5 | 42·5 | 50 | 47 | 45 | 51 | 43 | 47 | 36·5 | 50 | 46·4 |
| October, | 40 | 50 | 40 | 45 | 43 | 50 | 42 | 55 | 51·5 | 43 | 45·8 |
| November, | 37 | 34 | 43 | 42 | 39 | 46 | 59 | 44 | 40 | 64 | 44·9 |
| December, | 45 | 42 | 45 | 42 | 47 | 49 | 45 | 48 | 62 | 36 5 | 46·2 |
| Annual means, | | 98 | 88 | 94·5 | 96 | 105 | 99 5 | 86·5 | 99 | 94·5 | 95·7 |
| Winter, | | 64 | 53 | 50 | 63 | 65 | 73 5 | 53 | 65 | 70 | 61·8 |
| Spring, | | 63·5 | 70 | 63 | 71 | 79·5 | 77·5 | 74 | 67 | 65 | 70·1 |
| Summer, | | 46 | 47 | 51·5 | 44 | 53 | 44 | 43·5 | 55 | 43·5 | 47·5 |
| Autumn, | 66 | 59 | 70 | 67 | 62 | 67 | 68 | 66 | 55 | 76 | 65·6 |

MARCH.—The temperature of the first three days of March, 1861, was unusually high, reaching 78½° on the afternoon of the 3d. The highest point reached previously during this month, in the last ten years, was 75°, in March, 1854. During the morning of the 4th, the wind changed from the south-west to the north-west, and the temperature fell rapidly. At 2 P. M., it was 19° lower than at the same hour on the preceding day; and at 2 P. M., on the 5th, it was 19° lower than at the same hour on the 4th. So that the difference of temperature at that hour, in two days, amounted to 38°.

On the 9th of the month, rain began to fall early in the morning, and continued until 3 P. M., when the sky cleared off beautifully, and continued clear all the evening. At about 8 P. M., a splendid *aurora* was observed. It first appeared like a bright greenish light, extending from about 10° above the northern horizon, to a height of 40°. At 9 P. M., streamers appeared of a greenish hue at the north, and red towards the north-east and north-west, extending up to beyond

the Great Bear, which was then but very little east of the meridian. At 9½, green streamers appeared, reaching up to irregular and unequal heights, some of them extending as high as the constellation of the Great Bear. The whole of the northern half of the sky was illuminated. The light was green in the north, and red towards the east and west. At 9¾, a bright detached pencil of white or greenish white light was observed, stretching from the east directly west, about 10° south of the zenith, about 3° in width; red light in the north-west. At 10 P. M., the auroral light was still visible, but no streamers or pencils, and the light was gradually fading away.

On the 14th, the temperature fell to the freezing point in the morning, and at 9½ A. M., a fine snow began to fall, which continued till 1 P. M., when it was about two inches deep on the ground. At that time it changed to a drizzling hail, and soon afterwards to rain, which continued till 6 P. M., when the snow re-commenced. It stopped some time during the night. This snow-storm extended towards the south as far as Georgia. At Norfolk, Va., it commenced early on the 15th. It reached Augusta, Ga., on the night of the 18th, where it is reported to have fallen to the depth of six or eight inches.

On the 19th, snow to the depth of about one inch, fell at Philadelphia. About 8 P. M. on the 20th, snow began to fall, and continued at intervals until 11 P. M. on the 21st, melting as it fell. It began at about the same time at Easton, Pa , and extended from Norfolk, Va., to beyond St. Johns, N. B. At noon on the 19th, it was reported to be twelve inches deep at Norfolk. At Boston on the 21st, it was said to have been the thickest snow-storm of the season. On the 19th at Bangor, Me., the snow in the streets was from two to four feet deep, and the fields were covered to the depth of three feet. A letter from St. John, N. B., dated March 24th, states that there was then at least seven feet of snow on the level, while in the streets of the city, it was from twelve to fifteen feet deep.

On the 27th, rain began to fall early in the morning, and continued with great violence until 4½ P. M. It was accompanied by thunder and lightning from 11½ A. M. till 12 M., and from 2½ till 4 P. M. At 3 P. M., a very bright flash of lightning, which appeared to be of a reddish hue, was followed almost instantly by an extraordinarily sharp and loud clap of thunder.

The average temperature of the month, as will be seen by the following table, was two degrees lower than that of March of 1860, but still more than a degree above the average for the last ten years.

The mean daily range, showing the changes of temperature from day to day, was more than two degrees greater than usual.

The thermometer reached its maximum of 78½° on the 3d of the month, which was also the warmest day, the mean temperature being 66°.

The minimum temperature was 16°, and occurred on the 18th of the month. The coldest day was the 18th, the mean temperature being 23°.

The range of temperature for the month was $62\frac{1}{2}°$.

The temperature was below the freezing point on fifteen days of the month, but it rose above that point some time during every day, except on the 18th and 19th, when the highest point reached was $30\frac{1}{2}°$.

The pressure of the atmosphere was greatest (30·386 ins.) on the morning of the 8th, and least (29·354 ins.) on the afternoon of the 9th; making the range for the month, 1·032 inches. The mean pressure was greatest on the 8th and least on the 3d of the month. The mean daily range or average of changes of pressure was four-hundredths of an inch greater than usual, and one-tenth of an inch greater than it was in the month of March of last year.

The force of vapor and relative humidity were less, though the amount of precipitation in the form of rain and snow was greater than usual. The quantity of rain and melted snow (3·903 ins.) was thrice as much as that which fell in March, 1860, and over an inch more than the average for the last ten years. Snow fell on four days, and rain on five days of the month. The number of rainy days was nine, being one less than the average number for the month of March.

There were but two days on which the sky was entirely clear or free from clouds, and two on which the sky was completely covered with clouds, at the hours of observation.

*A Comparison of some of the Meteorological Phenomena of* MARCH, 1861, *with those of March*, 1860, *and of the same month for ten years, at Philadelphia.*

| | March, 1861. | March, 1860. | Mar., 10 years. |
|---|---|---|---|
| Thermometer.—Highest, | 78·5° | 73·0° | 78·5° |
| " Lowest, | 16·0 | 25·0 | 4·0 |
| " Daily oscillation, | 18·18 | 18·30 | 15·04 |
| " Mean daily range, | 8·66 | 5·40 | 6·36 |
| " Means at 7 A. M., | 37·73 | 38·15 | 35·92 |
| " " 2 P. M., | 48·71 | 52·34 | 47·48 |
| " " 9 P. M., | 41·58 | 43·71 | 40·72 |
| " " for the month, | 42·67 | 44·73 | 41·37 |
| Barometer.—Highest, | 30·386 in. | 30·224 in. | 30·522 in. |
| " Lowest, | 29·354 | 29·499 | 29·158 |
| " Mean daily range, | ·231 | ·133 | ·195 |
| " Means at 7 A. M., | 29·917 | 29 829 | 29·853 |
| " " 2 P. M., | 29 862 | 29·757 | 29 796 |
| " " 9 P. M., | 29·906 | 29·795 | 29 830 |
| " " for the month, | 29·895 | 29·794 | 29·826 |
| Force of Vapor.—Means at 7 A. M., | ·175 in. | ·171 in. | ·166 in. |
| " " " 2 P. M., | ·182 | ·175 | ·183 |
| " " " 9 P. M., | ·185 | ·182 | ·182 |
| Relative Humidity.—Means at 7 A. M., | 69 per ct. | 71 per ct. | 73 per ct. |
| " " " 2 P. M., | 48 | 44 | 53 |
| " " " 9 P. M., | 66 | 61 | 67 |
| Rain and melted snow, | 3·903 in. | 1·323 in. | 2·700 in. |
| No. of days on which rain or snow fell, | 9 | 8 | 10 |
| Prevailing winds, | N 73°37′ W ·328 | N 79°17′ W ·224 | N 76°25′ W ·312 |

*Abstract of Meteorological Observations for February, 1861; made in Philadelphia, Adams, and Franklin Counties, Pennsylvania, for the Committee on Meteorology of the Franklin Institute.*

PHILADELPHIA.—Lat. 39° 57′ 28″ N. Long. 75° 10′ 28″ W. Height above the sea 50 feet. Prof. J. A. KIRKPATRICK, Observer.

| 1861. Feb. | Barometer. Mean. | Barometer. Mean daily range | Thermometer. Mean. | Thermometer. Daily oscillation. | Thermometer. Mean daily range. | Force of vapor. 2 P.M. | Relative humidity. 2 P.M. | Dew point. 2 P.M. | Clouds. Sky cover'd | Rain and snow. | Prevail'g winds. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Inch. | Inch. | ° | ° | ° | Inch. | Per ct. | ° | Tenths. | Inch. | Direc. |
| 1 | 29·975 | ·033 | 30·5 | 18 | 7·3 | ·134 | 64 | 24·9 | 8 | } 0·470 | (var.) |
| ☾ 2 | 29·640 | ·336 | 47·8 | 14 | 17·3 | ·347 | 96 | 49·0 | 10 | | S W. |
| 3 | 30·127 | ·487 | 36·3 | 6 | 11·5 | ·127 | 60 | 23·7 | 10 | | N N W |
| 4 | 30·156 | ·085 | 33·2 | 8¼ | 3·8 | ·177 | 80 | 31·5 | 5 | | N W. |
| 5 | 30·051 | ·105 | 36·3 | 15 | 3·5 | ·131 | 49 | 24·4 | 6 | | W. |
| 6 | 29·768 | ·283 | 38·3 | 16 | 2·7 | ·099 | 32 | 18·1 | 1 | | S S W |
| 7 | 29·593 | ·375 | 27·8 | 35 | 13·5 | ·200 | 78 | 34·5 | 7 | 0·047 | S S W |
| 8 | 30·397 | ·804 | 8·2 | 17 | 25·3 | ·046 | 68 | 1·4 | 1 | | W N W |
| ● 9 | 30·451 | ·073 | 27·7 | 22 | 19·5 | ·100 | 51 | 18·3 | 8 | | S E. |
| 10 | 30·347 | ·145 | 46·7 | 23 | 19·0 | ·280 | 69 | 43·2 | 9 | | S. |
| 11 | 30·069 | ·238 | 52·3 | 16 | 5·7 | ·331 | 69 | 47·9 | 9 | | S. |
| 12 | 29·682 | ·387 | 51·2 | 16 | 6·5 | ·288 | 49 | 43·9 | 5 | 0·495 | (var.) |
| 13 | 30·019 | ·338 | 46·5 | 18 | 7·7 | ·115 | 26 | 21·4 | 4 | | W. |
| 14 | 29·997 | ·165 | 41·7 | 14 | 4·8 | ·161 | 46 | 29·1 | 6 | } 0·452 | (var.) |
| 15 | 29·529 | ·469 | 41·0 | 6 | 4·7 | ·234 | 91 | 38·5 | 10 | | N E. |
| 16 | 29·609 | ·246 | 44·7 | 21 | 5·0 | ·153 | 36 | 27·9 | 6 | 0·083 | W. |
| ☽ 17 | 29·595 | ·246 | 38·7 | 13 | 6·0 | ·111 | 39 | 20·6 | 6 | | W N W |
| 18 | 29·810 | ·215 | 33·3 | 9¼ | 5·3 | ·127 | 60 | 23·7 | 7 | | S W. |
| 19 | 29·910 | ·147 | 34·3 | 14 | 1·7 | ·115 | 47 | 21·5 | 6 | | W. |
| 20 | 29·569 | ·312 | 35·8 | 13 | 5·5 | ·157 | 53 | 28·6 | 8 | 0·322 | W. |
| 21 | 29·773 | ·208 | 35·0 | 9 | 4·8 | ·060 | 25 | 7·1 | 2 | | W. |
| 22 | 30·047 | ·270 | 38·5 | 16 | 6·2 | ·080 | 27 | 13·4 | 5 | | (var.) |
| 23 | 29·728 | ·319 | 50·3 | 22 | 11·8 | ·225 | 47 | 37·5 | 10 | 0·255 | (var.) |
| ○ 24 | 29·848 | ·242 | 36·7 | 27 | 17·7 | ·089 | 41 | 15·9 | 5 | | W S W |
| 25 | 30·300 | ·452 | 33·2 | 18¼ | 9·5 | ·088 | 33 | 15·6 | 0 | | S W. |
| 26 | 30·118 | ·182 | 45·0 | 21 | 11·8 | ·202 | 48 | 34·8 | 5 | | S S W |
| 27 | 30·152 | ·058 | 52·3 | 25¼ | 7·3 | ·210 | 34 | 35·8 | 3 | | S W. |
| 28 | 30·064 | ·088 | 56·2 | 26¼ | 3·8 | ·345 | 50 | 48·8 | 3 | | W N W |
| Means | 29·939 | ·264 | 39·5 | 17¼ | 8·9 | 169 | 52¼ | 27·9 | 6 | 2·124 | S 77° W |

GETTYSBURG, Adams Co. Lat. 39° 49′ N. Long. 77° 18′ W. Ht. 624 ft. Prof. M. JACOBS, Obs.

| 1861. Feb. | Barom. Mean. | Thermom. Mean. | Thermom. Mean daily range. | Rain and snow. | Prevail'g winds. |
|---|---|---|---|---|---|
| | Inch. | ° | ° | Inch. | Direc. |
| 1 | 29·456 | 21·3 | 5·7 | } 0·651 | W. |
| 2 | 29·186 | 40·3 | 19·0 | | S W. |
| 3 | 29·699 | 33·7 | 6·7 | | N W. |
| 4 | 29·730 | 30·0 | 3·7 | | (var.) |
| 5 | 29·610 | 26·0 | 4·0 | | S S W. |
| 6 | 29·301 | 35·7 | 6·3 | | S W. |
| 7 | 29·196 | 19·3 | 17·7 | | N W. |
| 8 | 29·955 | 4·7 | 20·7 | | (var.) |
| 9 | 29·985 | 25·3 | 20·7 | | S. |
| 10 | 29·881 | 39·0 | 13·7 | | S S W. |
| 11 | 29·521 | 46·3 | 7·3 | | S S W. |
| 12 | 29·252 | 46·7 | 6·3 | 0·690 | W N W |
| 13 | 29·571 | 38·3 | 8·3 | | W. |
| 14 | 29·469 | 37·0 | 3·3 | } 0·830 | N N E. |
| 15 | 29·016 | 39·3 | 3·0 | | N W. |
| 16 | 29·030 | 36·0 | 3·3 | | S S W. |
| 17 | 29·128 | 32·7 | 3·3 | | N W. |
| 18 | 29·388 | 29·3 | 3·3 | | W N W |
| 19 | 29·132 | 29·0 | 3·0 | 0·210 | S S W. |
| 20 | 29·132 | 35·3 | 6·3 | 0·010 | (var.) |
| 21 | 29·391 | 31·3 | 4·0 | | N W. |
| 22 | 29·583 | 35·3 | 4·0 | | W. |
| 23 | 29·206 | 44·3 | 9·0 | | S S W. |
| 24 | 29·460 | 31·3 | 18·3 | | N W. |
| 25 | 29·814 | 30·7 | 6·7 | | S S W. |
| 26 | 29·702 | 39·7 | 7·0 | | S S W. |
| 27 | 29·731 | 46·0 | 6·3 | | (var.) |
| 28 | 29·631 | 52·7 | 6·7 | | W. |
| Means | 29·481 | 34·0 | 8·1 | 2·421 | N 87° W |

CHAMBERSBURG, Franklin Co. Lat. 39° 58′ N. Long. 77° 45′ W. Height 618 ft. WM. HEYSER, Jr., Observer.

| 1861. Feb. | Barom. Mean. | Thermom. Mean. | Thermom. Mean daily range. | Force of vapor. 2 P.M. | Relative humidity. 2 P.M. | Dew point. 2 P.M. | Rain and snow. | Prevail'g winds. |
|---|---|---|---|---|---|---|---|---|
| | Inch. | ° | ° | Inch. | Per ct | ° | Inch. | Direc. |
| 1 | 29·283 | 24·3 | 5·3 | ·083 | 54 | 13·9 | 0·435 | (var.) |
| 2 | 29·027 | 42·7 | 18·3 | ·251 | 81 | 40·3 | | W. |
| 3 | 29·534 | 33·7 | 9·0 | ·127 | 61 | 23·7 | | (var.) |
| 4 | 29·561 | 31·7 | 2·7 | ·136 | 62 | 25·0 | | (var.) |
| 5 | 29·455 | 30·7 | 1·7 | ·165 | 72 | 29·6 | | E. |
| 6 | 29·135 | 37·0 | 6·3 | ·113 | 42 | 21·0 | | W. |
| 7 | 29·012 | 22·7 | 17·7 | ·050 | 31 | 4·0 | | W. |
| 8 | 29·760 | 8·0 | 19·3 | ·013 | 59 | —0·2 | | W. |
| 9 | 29·777 | 24·3 | 16·3 | ·100 | 65 | 18·3 | | (var.) |
| 10 | 29·696 | 35·3 | 11·0 | ·203 | 82 | 34·9 | | E. |
| 11 | 29·337 | 48·3 | 13·0 | ·251 | 61 | 40·5 | 0·250 | E. |
| 12 | 29·030 | 50·3 | 8·0 | ·153 | 37 | 27·9 | | W. |
| 13 | 29·438 | 42·0 | 8·3 | ·166 | 49 | 29·9 | | E. |
| 14 | 29·332 | 39·3 | 4·0 | ·156 | 49 | 28·4 | } 0·515 | E. |
| 15 | 28·874 | 41·0 | 3·0 | ·228 | 76 | 38·0 | | E. |
| 16 | 29·059 | 38·7 | 3·7 | ·134 | 41 | 24·8 | 0·445 | E. |
| 17 | 28·935 | 33·0 | 5·7 | ·142 | 70 | 26·3 | | W. |
| 18 | 29·240 | 32·0 | 1·0 | ·085 | 43 | 14·9 | | W. |
| 19 | 29·203 | 32·3 | 3·0 | ·085 | 43 | 14·9 | 0·150 | E. |
| 20 | 28·984 | 37·3 | 5·7 | ·208 | 75 | 35·4 | 0·050 | W. |
| 21 | 29·245 | 31·3 | 4·3 | ·149 | 70 | 27·3 | | W. |
| 22 | 29·423 | 38·0 | 6·3 | ·112 | 34 | 20·8 | 0·100 | E. |
| 23 | 29·056 | 36·3 | 8·3 | ·186 | 52 | 32·7 | | E. |
| 24 | 29·334 | 32·3 | 11·0 | ·149 | 70 | 27·4 | | W. |
| 25 | 29·652 | 31·3 | 7·0 | ·103 | 45 | 19·0 | | (var.) |
| 26 | 29·499 | 43·0 | 11·7 | ·131 | 29 | 24·4 | | W. |
| 27 | 29·561 | 47·0 | 4·3 | ·177 | 34 | 31·5 | | W. |
| 28 | 29·477 | 51·3 | 4·7 | ·203 | 32 | 34·9 | | W. |
| Means | 29·331 | 36·0 | 8·0 | ·146 | 54 | 25·3 | 1·945 | N 59° W |

*Abstract of Meteorological Observations for February,* 1861; *made in Somerset, Dauphin, and Northumberland Counties, Pennsylvania, for the Committee on Meteorology of the Franklin Institute.*

**Somerset, Somerset Co.** Lat. 40° N. Long. 79° 3′ W. Height 2195 feet. Geo. Mowry, Observer.

| 1861. Feb. | Barom. Mean. | Thermom. Mean. | Thermom. Mean daily range. | Force of vapor. 2 P. M. | Relative humidity. 2 P. M. | Dew point. 2 P. M. | Clouds. Sky covered. | Rain and snow. | Prevail'g winds. |
|---|---|---|---|---|---|---|---|---|---|
| | Inch. | ° | ° | Inch. | Per ct. | ° | Tenths. | Inch. | Direc. |
| 1 | 27 447 | 31·0 | 13·7 | ·175 | 89 | 31·7 | 10 | 0·343 | S. |
| ☾ 2 | 27·330 | 44·0 | 13·7 | ·285 | 85 | 43·3 | 10 | | W. |
| 3 | 27.795 | 27·7 | 16·3 | ·153 | 88 | 28·7 | 10 | | W N W |
| 4 | 27·808 | 29·3 | 1·7 | ·147 | 78 | 28·3 | 7 | | (var.) |
| 5 | 27·721 | 32·3 | 3·0 | ·234 | 91 | 38·7 | 10 | | W. |
| 6 | 27·475 | 32·7 | 5·7 | ·130 | 55 | 27·3 | 5 | | W. |
| 7 | 27·327 | 17·3 | 24·7 | ·097 | 92 | 18·8 | 9 | 0·180 | W N W |
| 8 | 27 870 | 9 3 | 22·0 | ·103 | 73 | 21·3 | 5 | | S W. |
| ● 9 | 27·910 | 28·3 | 19·0 | ·260 | 78 | 41·0 | 8 | | S. |
| 10 | 27·901 | 45·7 | 17·3 | ·315 | 71 | 45·5 | 8 | | S. |
| 11 | 27·577 | 50·7 | 6·3 | ·362 | 87 | 49·3 | 10 | | S. |
| 12 | 27·411 | 41·7 | 9·0 | ·188 | 56 | 34·0 | 2 | | W. |
| 13 | 27·705 | 37·7 | 4·0 | ·188 | 56 | 34·0 | 4 | | W. |
| 14 | 27·522 | 39·7 | 3·3 | ·238 | 77 | 39·0 | 10 | 0·395 | E S E |
| 15 | 27 202 | 37·3 | 2·3 | ·215 | 79 | 37·2 | 10 | 0·267 | (var.) |
| 16 | 27·222 | 31·3 | 2·7 | 183 | 90 | 32·7 | 7 | 0·341 | S E. |
| ☽ 17 | 27 243 | 30·7 | 6·3 | ·170 | 80 | 31·3 | 9 | 0·084 | W. |
| 18 | 27·507 | 23·3 | 7·3 | ·121 | 75 | 24·3 | 10 | | W. |
| 19 | 27 475 | 28·0 | 4·7 | ·169 | 84 | 31·5 | 10 | 0·076 | (var.) |
| 20 | 27·274 | 37·0 | 9·0 | ·169 | 54 | 32·0 | 10 | | W. |
| 21 | 27·571 | 28·0 | 9·0 | ·103 | 45 | 24·0 | 5 | 0·023 | W. |
| 22 | 27·686 | 39·7 | 11·7 | ·196 | 52 | 34·7 | 10 | | S W. |
| 23 | 27·350 | 53·3 | 13·7 | ·234 | 59 | 45·5 | 10 | | S W. |
| ○ 24 | 27·677 | 22·7 | 30·7 | ·074 | 57 | 17·0 | 8 | | W N W |
| 25 | 27 868 | 32·3 | 20·3 | ·165 | 49 | 31·7 | 4 | | S. |
| 26 | 27·811 | 45·7 | 13·3 | ·230 | 55 | 37·7 | 5 | | (var.) |
| 27 | 27·881 | 48·3 | 2·7 | ·309 | 60 | 43·7 | 5 | | W. |
| 28 | 27·834 | 53·3 | 5·0 | 365 | 60 | 47·5 | 5 | | W. |
| Means | 27·587 | 35·6 | 10·7 | ·203 | 70 | 34·0 | 8 | 1·715 | s 64° w |

**Harrisburg, Dauphin Co.** Lat. 40° 16′ N. Long. 76° 50′ W. Height, 300 feet. John Heisely, M.D., Observer.

| 1861. Feb. | Barom. Mean. | Thermom. Mean. | Thermom. Mean daily range. | Force of vapor. 2 P. M. | Relative humidity. 2 P. M. | Dew point. 2 P. M. | Rain and snow. | Prevail'g winds. |
|---|---|---|---|---|---|---|---|---|
| | Inch. | ° | ° | Inch. | Per ct. | ° | Inch. | Direc. |
| 1 | 29·763 | 25·3 | 2·7 | ? | ? | ? | } 0·358 | (var.) |
| ☾ 2 | 29·433 | 41·3 | 16·0 | ·264 | 92 | 41·7 | | E. |
| 3 | 29·991 | 37·0 | 4·3 | ·172 | 72 | 30·7 | | (var.) |
| 4 | 30·016 | 32·7 | 4·0 | ·177 | 80 | 31·5 | | N E. |
| 5 | 29·897 | 34·0 | 2·0 | ·207 | 90 | 35·4 | | S E. |
| 6 | 29 565 | 38·3 | 4·3 | ·162 | 58 | 29·3 | | S W. |
| 7 | 29 440 | 28·0 | 15·0 | ·138 | 70 | 25·6 | | N W. |
| 8 | 30·263 | 9·7 | 21·0 | ? | ? | ? | | N W. |
| ● 9 | 30·306 | 27·3 | 17·7 | ·143 | 79 | 26·4 | | E. |
| 10 | 30·165 | 38·3 | 11·0 | ·211 | 82 | 35·9 | | E. |
| 11 | 29 836 | 48·7 | 10·3 | ·347 | 93 | 49·0 | } 0·655 | S. |
| 12 | 29·510 | 48·3 | 5 7 | ? | ? | ? | | W. |
| 13 | 29·848 | 42·3 | 6·0 | ·296 | 85 | 44·7 | | S W. |
| 14 | 29·784 | 40·7 | 2 3 | ·272 | 84 | 42·5 | | N E. |
| 15 | 29·320 | 40 0 | 3·3 | ·257 | 100 | 41·0 | } 0·300 | (var.) |
| 16 | 29·392 | 41·7 | 2·3 | ·223 | 69 | 37·3 | | S W. |
| ☽ 17 | 29·417 | 35·7 | 6·0 | ·142 | 62 | 26·3 | | W. |
| 18 | 29·659 | 33·0 | 2·7 | ·177 | 80 | 31·5 | | W. |
| 19 | 29·710 | 33·7 | 1·3 | ·148 | 70 | 27·2 | | (var.) |
| 20 | 29·399 | 39·0 | 5·3 | ·207 | 75 | 35·4 | 0·312 | N W. |
| 21 | 29·653 | 36·0 | 3·0 | ·150 | 63 | 27·5 | | N W. |
| 22 | | | | | | | | |
| 23 | 29·492 | 45·0 | | ·250 | 84 | 40·3 | | E. |
| ○ 24 | 29·721 | 36·7 | 12·3 | ·164 | 71 | 29·6 | | N W. |
| 25 | 30·126 | 34·0 | 8·7 | ·158 | 64 | 28·8 | | S W. |
| 26 | 29·951 | 38·7 | 4·7 | ·211 | 82 | 35·9 | | S W. |
| 27 | 30·026 | 45·7 | 7·7 | ·266 | 61 | 41·9 | | S W. |
| 28 | 29·921 | 52·0 | 6 3 | ·397 | 71 | 52·6 | | S W. |
| Means | 29·859 | 37·2 | 7·2 | | | | 1·625 | s 79° w |

**Shamokin, Northumberland Co.**—Lat. 40° 45′ N. Long. 76° 30′ W. Height, 700 feet. P. Friel, Observer.

| 1861. Feb. | Barom. Mean. | Thermom. Mean. | Thermom. Mean daily range. | Force of Vapor. 2 P. M. | Relative humidity. 2 P. M. | Dew point. 2 P. M. | Rain and snow. | Prevail'g winds. |
|---|---|---|---|---|---|---|---|---|
| | Inch. | ° | ° | Inch. | Per ct. | ° | Inch. | Direc. |
| 1 | 29·274 | 21·0 | 1·5 | ·120 | 61 | 22·4 | 0·371 | E. |
| ☾ 2 | 28·908 | 45·2 | 24·5 | ·291 | 89 | 44·2 | | E. |
| 3 | 29·467 | 32·8 | 12·3 | ·142 | 70 | 26·2 | | W. |
| 4 | 29·469 | 31·7 | 3·2 | ·103 | 45 | 19·0 | | W. |
| 5 | 29·394 | 28·3 | 4·0 | ·123 | 57 | 23·0 | | (var.) |
| 6 | 29·061 | 36·7 | 8·3 | ·097 | 39 | 17·7 | | W. |
| 7 | 28·578 | 31·0 | 15·0 | ·177 | 86 | 31·5 | | W. |
| 8 | 29·608 | 0·3 | 30·7 | ·036 | 72 | —4 2 | | W. |
| ● 9 | 29·685 | 21·3 | 21·0 | ·106 | 86 | 19·6 | | E. |
| 10 | 29·502 | 43·3 | 22·0 | ·260 | 78 | 41·3 | 0·062 | S E. |
| 11 | 29·299 | 53·3 | 10·0 | ·362 | 87 | 50·1 | | E. |
| 12 | 29·058 | 49·3 | 6·0 | ·407 | 87 | 53·2 | 0·765 | W. |
| 13 | 29·296 | 37·7 | 11·7 | ·228 | 76 | 37 9 | | W. |
| 14 | 29·270 | 36·3 | 2·7 | ·105 | 41 | 19·5 | 0·090 | W. |
| 15 | 28·683 | 39·5 | 5·5 | ·235 | 91 | 38·7 | | E. |
| 16 | 28·876 | 40·5 | 6 3 | ·238 | 77 | 38·9 | | E. |
| ☽ 17 | 28·808 | 33·3 | 8·5 | ·162 | 80 | 29·3 | 0·500 | W. |
| 18 | 29 054 | 29·2 | 4·2 | ·136 | 78 | 25·2 | | W. |
| 19 | 29·134 | 31·0 | 1·8 | ·168 | 89 | 30·2 | | W. |
| 20 | 28·703 | 35·8 | 4·8 | ·110 | 49 | 20·4 | 0·190 | W. |
| 21 | 29·031 | 30·3 | 5·5 | ·170 | 80 | 30·5 | | W. |
| 22 | 29·304 | 32·0 | 5·7 | ·129 | 61 | 24·0 | | W. |
| 23 | 28·931 | 45·3 | 14·3 | ·260 | 78 | 41·3 | 0·100 | E. |
| ○ 24 | 29·079 | 31·8 | 14·8 | ·168 | 89 | 30·2 | | N W. |
| 25 | 29·543 | 28·7 | 12·2 | ·170 | 80 | 30·5 | | S W. |
| 26 | 29·342 | 39 7 | 11·0 | ·231 | 83 | 38·2 | | W. |
| 27 | 29·451 | 44·0 | 11·7 | ·429 | 77 | 54·7 | | W. |
| 28 | 29·363 | 45·8 | 4·8 | ·478 | 83 | 57·8 | | W. |
| Means | 29·185 | 34·9 | 10·1 | ·201 | 63 | 31·8 | 2·078 | s 80 °w |

*Abstract of Meteorological Observations for February,* 1861; *made in Centre, Bradford, and Erie Counties, Pennsylvania, for the Committee on Meteorology of the Franklin Institute.*

| 1861. | Fleming, Centre Co. Lat. 40° 55′ N. Long. 77° 53′ W. Ht., 780 feet. S. Brugger, Observer. | | | | | Towanda, Bradford Co. 41° 47′ N. 76° 34′ W. Height, ab't 840 ft. S. J. Coffin, Observer. | | | | | Erie, Erie Co.—Lat. 42° 8′ N. Long. 80° 12′ W. Height about 640 feet. Benjamin Grant, Observer. | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Thermometer. | | Clouds. | Rain and snow. | Pre-vail'g winds. | Barom. | Thermometer. | | Clouds. | Pre-vail'g winds. | Barom | Thermometer. | | Force of Vapor. | Rela-tive humi-dity. | Dew point. | Clouds. | Pre-vail'g winds. |
| Feb. | Mean. | Mean daily range. | Sky covered. | | | Mean. | Mean. | Mean daily range. | Sky covered. | | Mean. | Mean. | Mean daily range. | 2 P. M. | 2 P. M. | 2 P. M. | Sky covered. | |
| | ° | ° | Tenths. | Inch. | Direc. | Inch. | ° | ° | Tenths. | Direc. | Inch. | ° | ° | Inch. | Per ct. | ° | Tenths. | Direc. |
| 1 | 16·0 | 0·7 | 9 | 0·325 | (var.) | 28·870 | 25·7 | 3·7 | 7 | S. | 29·100 | 30·3 | 9·3 | ·135 | 88 | 25·1 | 8 | S. |
| ☾ 2 | 38·0 | 22·0 | 10 | | N W. | 28·697 | 42·0 | 16·3 | 10 | (var.) | 29·047 | 37·0 | 16·0 | ·177 | 80 | 31·5 | 10 | W. |
| 3 | 28·3 | 9 7 | 5 | | (var.) | 29·260 | 24·7 | 17·3 | 6 | (var.) | 29·621 | 27·0 | 10·0 | ·123 | 77 | 22 9 | 10 | N. |
| 4 | 25·0 | 3·3 | 3 | | W. | 29·233 | 26·0 | 4·7 | 4 | (var.) | 29·537 | 33·0 | 6 0 | ·127 | 60 | 23·7 | 8 | W. |
| 5 | 30·7 | 5·7 | 9 | | W. | 29·110 | 32·7 | 6·7 | 10 | (var.) | 29 405 | 32·3 | 1·3 | ·148 | 70 | 27·2 | 10 | W. |
| 6 | 34·0 | 6·0 | 3 | | W. | 28·733 | 35·7 | 3·0 | 2 | (var.) | 29·026 | 35·3 | 3·7 | ·129 | 54 | 24·0 | 8 | W. |
| 7 | 18·3 | 31·0 | 6 | 0 100 | N W. | 28·637 | 12·0 | 29·7 | 8 | N W. | 29·141 | 11·3 | 24·0 | ·036 | 44 | — 3·9 | 7 | N W. |
| 8 | 1·3 | 27·0 | 3 | | S E. | 29·427 | 0·3 | 22·3 | 5 | N W. | 29·733 | 1·7 | 21·0 | ·052 | 100 | 4 0 | 8 | S W. |
| ● 9 | 22·0 | 20·7 | 3 | | W. | 29 450 | 21·3 | 21·0 | 7 | (var.) | 29·508 | 29·3 | 27·7 | ·124 | 69 | 23·2 | 4 | S E. |
| 10 | 34·0 | 12·0 | 8 | | (var.) | 29·350 | 44·7 | 23·3 | 7 | S. | 29·551 | 54·0 | 24·7 | ·438 | 88 | 55·3 | 6 | S. |
| 11 | 45·0 | 11·0 | 10 | 0·770 | W. | 29·023 | 53·0 | 8·3 | 9 | S. | 29·064 | 55·3 | 2·0 | ·334 | 69 | 47 9 | 8 | S. |
| 12 | 42·7 | 5·0 | 4 | | W. | 28·730 | 49·3 | 4·3 | 5 | W. | 29·016 | 42·0 | 13·3 | ·142 | 62 | 26·3 | 5 | W. |
| 13 | 33·0 | 9·7 | 3 | | W. | 29·090 | 38·3 | 13·0 | 3 | (var.) | 29·421 | 34·7 | 7·3 | ·142 | 62 | 26·3 | 3 | W. |
| 14 | 33·7 | 7·0 | 10 | 0·820 | S E. | 29·090 | 37·3 | 5·0 | 10 | S. | 29·192 | 38·7 | 4·0 | ·216 | 90 | 36·4 | 10 | E. |
| 15 | 39·7 | 4·3 | 8 | | S W. | 28·567 | 40·0 | 3·3 | 9 | (var.) | 28·821 | 40·3 | 5·7 | ·211 | 82 | 35·9 | 10 | S W. |
| 16 | 35·7 | 4·0 | 7 | 0·480 | W. | 28·617 | 40·0 | 4·7 | 7 | (var.) | 28·927 | 35·0 | 5·3 | ·102 | 40 | 18·7 | 6 | W. |
| ☽ 17 | 29·7 | 6·7 | 9 | | W. | 28·587 | 32·3 | 7·7 | 10 | W. | 28·951 | 30·7 | 4·3 | ·150 | 79 | 27·5 | 9 | N W. |
| 18 | 26·3 | 3·3 | 10 | | W. | 28·870 | 29·7 | 2·7 | 10 | N W. | 29·223 | 31·3 | 3·3 | ·204 | 100 | 35·0 | 10 | S W. |
| 19 | 29·0 | 4·7 | 10 | 0·100 | W. | 28·913 | 32·7 | 3·0 | 10 | S W. | 29·104 | 32·0 | 3·3 | ·150 | 79 | 27·5 | 9 | S E. |
| 20 | 31·3 | 2·3 | 3 | | W. | | | | | E. | 28·951 | 36·0 | 6·7 | ·158 | 64 | 28 8 | 10 | W. |
| 21 | 29·3 | 2·7 | 4 | | N W. | 28·847 | 27·7 | | 6 | N W. | 29·303 | 31·0 | 5·0 | ·112 | 59 | 20·9 | 5 | W. |
| 22 | 33·0 | 7·0 | 0 | | W. | 29·103 | 28·7 | 5·0 | 7 | N W. | 29·374 | 32·7 | 3·0 | ·143 | 79 | 26·4 | 10 | S. |
| 23 | 37·7 | 4·7 | 9 | 0·500 | (var.) | 28·663 | 45·0 | 16·3 | 9 | S W. | 28·901 | 48·0 | 15·3 | ·253 | 61 | 40·6 | 10 | S W. |
| ○ 24 | 26·7 | 11·0 | 4 | | N W. | 28·983 | 24·0 | 21·0 | 4 | N W. | 29·470 | 24·0 | 24·0 | ·072 | 59 | 11·4 | 5 | N. |
| 25 | 26·3 | 11·7 | 1 | | W. | 29·283 | 29·0 | 15·7 | 3 | (var.) | 29·304 | 38·7 | 15·3 | ·061 | 21 | 7·7 | 4 | S W. |
| 26 | 31·0 | 6·7 | 4 | | W. | 29·180 | 40·7 | 11·7 | 3 | (var.) | 29·439 | 43·7 | 7·7 | ·203 | 68 | 34·9 | 2 | W. |
| 27 | 41·7 | 10·7 | 3 | | W. | 29·260 | 41·7 | 6·3 | 1 | (var.) | 29·535 | 48·7 | 5 0 | ·211 | 42 | 35·9 | 1 | W. |
| 28 | 46·0 | 4·3 | 1 | | W. | 29·143 | 49·7 | 8·0 | 2 | W. | 29·394 | 58·7 | 10·0 | ·404 | 63 | 53·1 | 6 | W. |
| Means | 30 9 | 9·1 | 6 | 3·095 | s 83° w | 28·985 | 33·5 | 10·8 | 6 | s 80° w | 29·254 | 35·5 | 10·1 | ·170 | 68 | 27·6 | 7 | s 66° w |

JOURNAL

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FOR THE

PROMOTION OF THE MECHANIC ARTS.

JUNE, 1861.

# CIVIL ENGINEERING.

## *On the Construction of a Rigid Suspension Bridge.* By C. Köpcke, Geestemünde, Hanover.

From the Civ. Eng. and Arch. Jour., Jan., 1861.

The vertical vibrations to which the common suspension bridges are to a great extent subjected have much restricted the application of these structures, and rendered them unsuitable for railway purposes. Several proposals have lately been made to stiffen the suspension bridges, but none of these appear to answer the purpose in a simple and safe manner. The construction to be here described, as shown in Fig. 1 [next page], consists essentially of two rigid beams suspended on the pillars, and connected by means of hinges, and so curved as to sustain only a strain similar to that of a chain when loaded equally over the whole length, but being strong and rigid enough to counteract the undulations resulting from a heavy transit load (Fig. 2). The calculation of the strain in the different parts is based on the theory of the line of tension, which has here a similar application as the line of pressure in the calculation of arches. The essential difference, however, is this: that in an arch, several lines of pressure can always be drawn, every one of which gives a different result in respect to the strain on the material, so that it remains undecided which line of pressure will actually come into operation. Moreover, in an arch, the line alters its form according to the tempe-

rature, and in consequence of the starting points at the crown and in the abutments not always being the same.

Fig. 1.

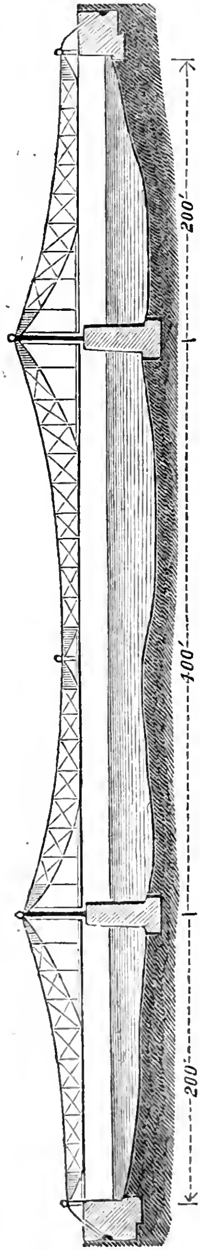
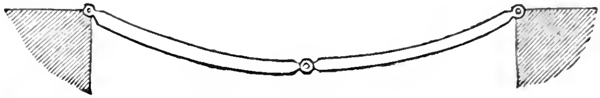



Fig. 2.



In using hinges which will allow of the beams moving vertically by change of temperature at the points of suspension, as well as in the middle of the opening, the line of tension is at once fixed; it must necessarily pass through those three points, and its form can be ascertained with the utmost precision for any position of the load brought upon the bridge.

Now, when the form of the line for a special case is found, it will be possible to calculate the strain on the main chain as well as on the bottom flanch, both being connected by lattice-work or diagonal bracing.

Fig. 3.

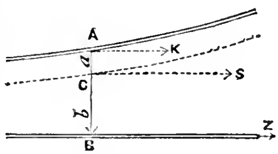
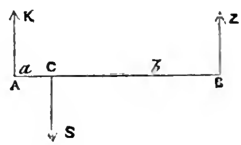



Fig. 4.



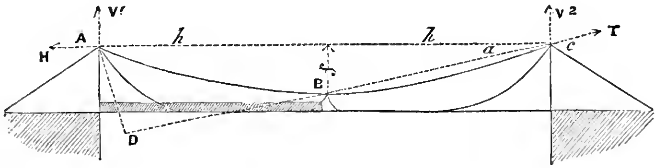

Let A (Fig. 3) be the main chain, B the bottom beam, and C a point of the line of tension calculated for a special case, having the distances $a$ and $b$ from the chain and the beam, respectively. The horizontal strain in the line of tension may be called S; that on the chain, K; and that on the beam Z; then there will subsist a relation between the different strains similar to that of a beam resting on two supports and being loaded at a certain point of its length (Fig. 4), viz:—$K \cdot a = Z \cdot b$, and $Z + K = S$, so that

$$K = S \cdot \frac{b}{a+b}, \text{ and } Z = S \cdot \frac{a}{a+b}.$$

To get the calculation of the line of tension as simple as possible, suppose both the constant and the moving load uniformly distributed over the horizontal projection, whence the line of tension will be a parabola. In case of the load not being spread over the whole length, the line of tension will be composed of parts of two different parabolæ. The tension of the main chain or rope when loaded on its whole length, is so easily determined, that it is not necessary to give the calculation, but to take under consideration here only the bottom

flanch and the lattice-work or diagonal bracing, when one-half of the span, or, what will be the same, one of the two suspended beams, is continually loaded with the passing weight, and the other half unloaded (Fig. 5).

FIG. 5.




Let the half-span be $= h$, and the height of the points of suspension above the junction in the centre $= f$, the permanent load $= q$, the moving load $= p$, per unity of length.

Now, we may assume the unloaded half $\overline{\mathrm{BC}}$, considering its construction as a beam, to be a firm connecting piece between the points B and C, as it might also be effected by a rectilinear rope. The pressure on the support C, caused by the movable load may therefore be derived from the strain T of a rope $\overline{\mathrm{BC}}$, supposed to be weightless. Produce the line $\overline{\mathrm{CB}}$ to a point D, whence a line drawn normal to DC will pass through it, and let the length AD be equal to $s$, then we have the equation:

$$\mathrm{T} \,.\, s = \frac{p\,h^2}{2}, \quad \text{since } s = 2\,h \sin a,$$

$$\text{and } \sin a = \frac{f}{\sqrt{f^2 + h^2}}, \quad \mathrm{T} = \frac{p\,h}{4f}\sqrt{f^2 + h^2}.$$

The vertical component of this strain will be $= \mathrm{T} \sin a = \frac{p\,h}{4}$, and the horizontal component $= \mathrm{T} \cos a = \frac{p\,h^2}{4f}$.

The permanent load $q$, uniformly distributed over the whole length, causes in each of the two supports a vertical pressure $= qh$, and a horizontal strain $= \frac{q\,h^2}{2f}$; we have, therefore, the whole pressure in A,

$$\mathrm{V}_1 = qh + \tfrac{3}{4}ph = (q + \tfrac{3}{4}p)h,$$

and in C,

$$\mathrm{V}_2 = \left(q + \frac{p}{4}\right)h;$$

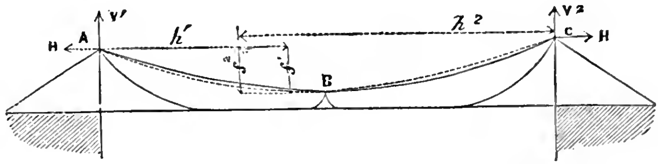
whereas, the horizontal strain throughout the whole length is

$$\mathrm{H} = \left(q + \frac{p}{2}\right)\frac{h^2}{2f}.$$

Having the value of $\mathrm{HV}_1$ and $\mathrm{V}_2$, it will now be possible to find the semi-chords, as well as the heights of the two parabolæ which compose

the line of tension and join in the middle hinge, whereby the line of tension will be entirely fixed (Fig. 6). As regards first the loaded

FIG. 6.




half, the horizontal distance $h_1$ of the vertex from the point A can be deduced from the vertical pressure in A, as follows:

$$(q+p)h_1 = V_1 = (q+\tfrac{3}{4}p)h,$$

therefore,

$$h_1 = \frac{q+\frac{3}{4}p}{q+p}h.$$

Further, the vertex of the parabola lies at a depth $f_1$ below the level of the points of suspension, to be found by the relation

$$f_1 H = (p+q)\frac{h_1^2}{2},$$

whence it becomes

$$f_1 = \frac{(q+\frac{3}{4}p)^2 f}{(q+p)\left(q+\frac{p}{2}\right)}.$$

Thus, the parabola which represents the line of tension in the loaded half can be drawn, the values of $f_1$ and $h_1$ being known. As regards the unloaded half, it is evident that the geometrical tangents to the line of tension at the middle hinge must be directed upwards towards C, because this hinge has to transfer the weight of $\frac{ph}{4}$. The vertex of the completed parabola, of which the line of tension between B and C forms a part, lies beyond the middle towards A, and as we call $q$ the weight upon the unity of length in a horizontal distance from B equal to $\frac{ph}{4q}$, then the semi-chord $h_2$ of the parabola from C to its axis will be

$$h_2 = h + \frac{ph}{4q} = \frac{p+4q}{4q}h.$$

The rise $f_2$ of this parabola may be determined by the relation $H \cdot f_2 = \frac{q h^2}{2}$, and substituting for H its value, it becomes

$$f_2 = f\frac{(p+4q)^2}{16q^2+8pq}.$$

Thus, the values $f_2$ and $h_2$ being known, the part of the parabola

which represents the line of tension in the unloaded half, is also determined.

By means of the relation between K, S, and Z, the strains on the chain and bottom flanch can now be determined for every special case. It is a matter of course that the most unfavorable mode of loading must be always assumed. In ascertaining, therefore, the strain of the chain, we have to consider the bridge as completely loaded, while only one-half of this load is to be taken into account in computing the tension of the lower member. To illustrate the case by an example, suppose

The moving load $p = 3500$ lbs.
The permanent weight $q = 2000$ lbs.
The span $2h = 400$ ft.
The height $f = 33\frac{1}{3}$ ft.
The height of the middle hinge above the bottom flanch $= 8$ ft.

Then the greatest strains on the chain and the bottom flanch are to be calculated as follows:—

In substituting the figures in the preceding equations, we get these results:

$h_1 = 168{\cdot}18$ ft. $\qquad f_1 = 34{\cdot}565$ ft.
$h_2 = 287{\cdot}5$ " $\qquad f_2 = 36{\cdot}76$ "

Let the middle hinge be now the point of origin, and the horizontal line through it the axis of abscissæ: then we get the following table of ordinates for the different lines of tension in each half of the bridge:—

| Abscissæ (Foot). | Ordinates (Foot). | | |
|---|---|---|---|
| | Total Load. | Partial Load. | |
| | | Loaded half. | Unload. half. |
| 20 | 0·333 | 1·056 | 1·71 |
| 40 | 1·333 | 1·154 | 3·80 |
| 60 | 3·000 | 0·274 | 6·25 |
| 80 | 5·333 | 1·583 | 9·05 |
| 100 | 8·333 | 4·419 | 12·21 |
| 120 | 12·000 | 8·231 | 15·71 |
| 140 | 16·333 | 13·022 | 19·56 |
| 160 | 21·333 | 18·790 | 23·80 |
| 180 | 27·000 | 25·536 | 28·39 |
| 200 | 33·333 | 33·333 | 33·33 |

The horizontal strain in the line of tension when the whole bridge is loaded, is equal to

$$\frac{(p+q)h^2}{2f} = \frac{(3500+2000)\,200^2}{2\,.\,33{\cdot}33} = 3{,}333{,}333 \text{ lbs.}$$

The strain at the point of suspension

$$= \sqrt{3{,}333{,}333^2 + (5500\,.\,200)^2} = 3{,}508{,}720 \text{ lbs.}$$

The horizontal strain in case of only one-half of the span being exposed to the moving load, is found to be $H = \left(q + \frac{p}{2}\right)\frac{h^2}{2f}$, or, in figures, $H = 2{,}250{,}000$ lbs.

The strain at the point of suspension on the side where the bridge is loaded, amounts to

$$= \sqrt{2{,}250{,}000^2 + (168 \cdot 18 \;.\; 5500)^2} = 2{,}433{,}000 \text{ lbs.},$$

and on the unloaded side,

$$= \sqrt{2{,}250{,}000^2 + (287 \cdot 5 \;.\; 2000)^2} = 2{,}322{,}000 \text{ lbs.}$$

When the bridge is not loaded at all, the horizontal strain equals

$$\frac{q\,h^2}{2f} = 1{,}200{,}000 \text{ lbs.},$$

and the strain at the point of suspension,

$$\sqrt{1{,}200{,}000^2 + (200 \;.\; 2000)^2} = 1{,}265{,}000 \text{ lbs.}$$

If we allow now a strain of 8500 lbs. per square inch, then the section of the main chains (which may be three in number for a double line of rails) must amount to $\frac{3{,}333{,}333}{8500} = 392$ square inches, or for each chain 131 square inches.

Concerning the bottom flanch it must be remarked, that as it lies horizontally supporting the ends of the cross beams, the area of its section must be varied. At 20 feet distance from the middle hinge, we have the ordinate of the main chain $= 0 \cdot 333$ feet, that of the line of tension on the loaded side $= -1 \cdot 056$ feet; the depth of the bottom beam below that line $= 8 - 1 \cdot 056 = 6 \cdot 944$ feet. The horizontal strain in the line of tension, the bridge being loaded unequally, $=$ 2,250,000 lbs. This strain is transferred partly to the chain, partly to the bottom beam, in proportion to the distances of each from the line of tension, so that the strain coming on the beam equals

$$z = \frac{0 \cdot 333 + 1 \cdot 056}{8 + 0 \cdot 333} \;.\; 2{,}500{,}000 \text{ lbs.}$$

$$z = 375{,}000 \text{ lbs.}$$

At 60 feet distance from the middle hinge we get

$$z = 685{,}000 \text{ lbs.}$$

At 100 feet distance, $z = 564{,}000$ "

At 140 feet distance, $z = 331{,}000$ "

Thence to the point of suspension a separate iron is applied, of such a form that the strain to which it is exposed remains constant. On this part of the bridge the roadway is merely supported by suspension rods (fastened on the main beams), as no diagonal trussing is required. These beams have no support at the ends, but provision must be made that no horizontal oscillation can result from their being at liberty to move laterally. On the unloaded side of the bridge, pressures result in the partly-horizontal partly-curved bottom beam, because the line

of tension passes above the main chain; but these pressures, which may be found by the above table in the same manner as the strains are found, are of no particular interest, since they become smaller than the strains at the same points when the bridge is loaded on this side. If it be considered preferable to avoid all pressure in the bottom beam, it would only be necessary to draw the elevation of the chain according to the line of tension in the unloaded side in case of single-sided loading; the consequence hereof would be that the bottom flanch would partake of the strain also in case of uniform loading, and therefore require to be made stronger, but always considerably less than double what is here calculated.

The differences of strain in the bottom member are compensated by the lattice-work or diagonal bracing (shearing effect), and may be calculated here in a similar way as in ordinary beams. This shearing effect is here considerably less than in beams without strain in the axis, therefore the lattice-work can have small dimensions and great openings. Plate iron of such a thinness as would be requisite here is hardly applicable; but it may be mentioned, that with respect only to the shearing force, the vertical plates (that is, of all three beams) would require a weight per square foot of elevation—

| | |
|---|---|
| At 20 feet distance from the middle hinge, of . | 3·057 lbs. |
| At 40 feet distance, . . | 2·393 " |
| At 100 feet distance, only . . | 0·064 " |

supposing the strain on the square inch to be 5000 lbs.

In arranging diagonal braces with 45° inclination, so as to resist the pulling forces only, and vertical posts against the crushing forces, this brace-work would require a weight nearly five times as much as that just calculated for plate iron.

The weight of a bridge of 400 feet span, approximately calculated, stands thus:—

| | lbs. |
|---|---|
| Main chains, of an average sectional area of 136 square inches, 3 . 136 . 400 . 3, . . . | 489,600 |
| Bottom flanch and beam carrying the railway— 2 . 3 . [60 ft. (40 sq. ins. + 60 sq. ins.) + 140 ft. . 80 sq. ins.] = | 103,200 |
| The brace-work has an average weight of 6 lbs. per superficial foot of the total area between frames— 3 . 2 . 2400 . 6 = | 86,400 |
| Cross-beams, arranged in plan like a net, to stiffen the bridge laterally against the effect of wind and passing loads—320 in number, 21 feet long, and weighing 30 lbs. per foot run, . | 201,600 |
| Suspension-rods, 1450 feet at 6 lbs., . . | 8,700 |
| Wind-braces between the main chains, . . | 10,000 |
| Rivets, &c., . . . . | 30,000 |
| Total weight in lbs., . . | 929,500 |

$$\text{Making per foot run, } \frac{929{,}500}{400} = 2324 \text{ lbs.}$$

Besides this, should be included 200 lbs. per foot run for rails, sleepers, and planking, increasing the constant weight to 2524 lbs. per foot run, whereas, before, only 2000 lbs. was assumed. This dif-

ference properly demands a fresh calculation under the supposition of 2524 lbs. constant weight; but, as it is not intended here to give an exact estimate for a special case, it will suffice to remark that, in keeping the dimensions found above, the strain on the main chain would increase from 8500 lbs. to

$$\frac{3500 + 2524}{3500 + 2000} \cdot 8500 = 9290 \text{ lbs. per square inch of section.}$$

It is evident that this system is also applicable to arched bridges, and that here the same advantages are to be obtained as in applying it to suspension bridges. The principal defect of wrought iron arched bridges as they are now usually constructed (and the best model of which is considered to be the Pont d'Arcole, Paris, projected by Cadiat and Oudry), cannot be obviated without the introduction of a hinge in the centre of the arch. For, if the arch is made somewhat high in the soffit in order to get it sufficiently rigid, the structure will be endangered by the influence of temperature. The increase of temperature produces an extension of the whole arch and a rise in the middle, the consequence of which will be that the upper flanch becomes more lengthened than the lower one. The amount of these mutations effected by the changes of temperature depends on the height of the arch. The Pont d'Arcole has ribs of only small rise in the centre, and therefore the influences of temperature are here less considerable; but this advantage is obtained at the expense of the strength of the ribs, which are more liable to deflect when a load passes over the bridge. This disadvantage is fully obviated by introducing a hinge in the centre—the arch can in that case freely extend and rise without being exposed to a dangerous strain, and the height can be made great enough not to admit of any detrimental deflection. As above defined, hinges should also be introduced at the abutments.

All uncertainties respecting the amount of the strain on the material, are now entirely removed. The amount of pressure can, therefore, be distinctly determined, so that all strains to which any parts of the structure may be subjected can be computed beforehand with exactness.

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Translated for the Journal of the Franklin Institute.

## *Examination of some Questions relative to Transportation.* By M. Lamarle, Chief Engineer "des Ponts et Chaussées." Translated by J. Bennett.

(Continued from page 298.)

We have endeavored to determine it in the ordinary circumstances of navigation, and we will indicate succinctly the principal results to which we have arrived in the case of animate motors, which the usual navigation employs almost exclusively upon our canals. They lead to the following rule: the number of motors to be employed to insure a minimum of expense should be equal to the ratio of price of hire of

boat to that of each motor. We may then easily deduce the velocity and net cost corresponding with this condition.

The following table indicates these values, for the different classes of boats, in two distinct cases:

1. The actual state of navigation, with a depth of 1·65 m. (5·41 ft.) and section of 18 square metres (21·5 square yards).

2. The increase in draft of water, which is now 6·56 ft. upon some lines, should approach a water section of 24 square metres (28·7 square yards).

| Designation. | Tonnage. | Going loaded. Velocity. | Going loaded. Expense per kilometre and per boat. | Going loaded. Expense per kilometre and per ton. | Returning empty. Velocity. | Returning empty. Expense per kilometre and per boat. | Returning empty. Expense per kilometre and per ton. | Total per ton going and returning. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|
| | | m. | fr. | fr. | m. | fr. | fr. | fr. | |
| Small boats, | 25 | 0·73 | 0·319 | 0·0128 | 0·90 | 0·200 | 0 0080 | 0·0208 | a |
| Medium boats, | 100 | 0·73 | 0·534 | 0·0053 | 0 90 | 0 262 | 0·0026 | 0 0079 | a |
| Bilanders, | 190 | 0·78 | 0·679 | 0·0036 | 0·90 | 0·324 | 0 0017 | 0 0053 | a |
| Great boats, | 225 | 0·62 | 0 797 | 0·0035 | 0 90 | 0·293 | 0 0013 | 0·0048 | a |
| Small boats, | 25 | 0·82 | 0·305 | 0·0122 | 0 90 | 0·200 | 0 0080 | 0·0202 | b |
| Medium boats, | 100 | 0·79 | 0·492 | 0·0049 | 0·90 | 0·262 | 0·0026 | 0 0075 | b |
| Bilanders, | 190. | 0·85 | 0·621 | 0·0033 | 0 90 | 0·324 | 0·0017 | 0·0050 | b |
| Great boats, | 270 | 0·60 | 0·834 | 0·0031 | 0·90 | 0·293 | 0·0011 | 0·0042 | b |

*a* Actual conditions: depth 5·41 ft., section 21·5 sq. yds., hauling with horses.

*b* New " " 6·56 " " 28·7 " " "

NOTE.—In the columns of velocity multiply by 2·236 for number of miles per hour. Multiply francs per kilometre per ton by 29·9 for cents per ton per mile.

These results apply to planes of water without locks and without velocity. To appreciate the increase of expense due to locks, it suffices to convert into kilometres the time consumed by the boat in passing them.

If we designate by $d$ the space between the locks, by V the velocity of the boat, and by $t$ the time lost at each lock, we shall have, for the time of passing the reach and lock, $t + \frac{d}{V}$ instead of $\frac{d}{V}$; whence, for the co-efficient of increase of expenses, $1 + \frac{V\,t}{d} = B$; the space corresponding to the passage of the lock is $V\,t$.

Generally we have $t = 3600''$, $V = 0{\cdot}55$ m. (1·8 ft.), whence

$$B = \frac{1{\cdot}98 \text{ k.}}{d} + 1, \text{ or } \left(B = \frac{1{\cdot}23 \text{ miles}}{d} + 1\right).$$

The expenses of navigation will thus be doubled for reaches of a

length of 1·98 k. (1·23 miles), quadrupled for $d = 0·66$ k. (0·41 miles), and decupled for the smallest reaches $d = 0·22$ k. (0·136 miles).

This cause of expense may be lessened in many ways:

1. By increasing the number of lock tenders, to hasten manœvring and to reduce the value of $t$.

2. By concentrating in each reach the motors employed in hauling, so that the boats only may lose the time consumed in passing the locks.

The first means would furnish upon frequented canals economies superior to the excess of expenditures which it would cost;* the second would reduce by about one-half the expense due to passing the locks; the use of these two means constitutes, then, an element of economy worth mentioning.

17. We have also sought to determine the influence exerted by the velocity of currents upon the cost of navigation, and we give in the following table the results applicable to the greatest sections and the largest boats.

| Velocity of current. | Velocity of boat. | Expense of Navigation. | | | | Force required. | |
|---|---|---|---|---|---|---|---|
| | | Ascending. | | Descending. | | Ascent. | Descent. |
| | | Co-efficients. | Absolute values. | Co-efficients. | Absolute values. | Increase. | Decrease. |
| metre. | metre. | | franc. | | franc. | | |
| 0·00 | 0·60 | 1·00 | 0·834 | 1·00 | 0·834 | 1·00 | 1·00 |
| 0·20 | 0·64 | 1·40 | 1·168 | 0·73 | 0 609 | 1·94 | 0·54 |
| 0·40 | 0·72 | 1·87 | 1·559 | 0·53 | 0·442 | 3·48 | 0·28 |
| 0·60 | 0·85 | 2·42 | 2·018 | 0·41 | 0·342 | 5·84 | 0·18 |
| 0·67 | 0·90 | 2·62 | 2·185 | 0·30 | 0·325 | 6 85 | 0·15 |

The usual velocities of the canaled rivers of the North are comprised in the limits of this table; it will thus admit of our accounting for the increased cost due to currents. Thus, for a river with a velocity of 0·2 m. (or 0·447 miles per hour) the co-efficients in ascending and descending are respectively 1·40 and 0·73; each kilometre ought then to be reckoned as 1·40 k. in ascending, and 0·73 k. in descending.

18. We might thus determine with an exactness sufficient for practice, the cost of navigation upon the mixed routes, comprised by the rivers and canals, as well as upon the most part of the great lines which are in special competition with the railroad.

We find, in applying the calculation to the trip from Mons to Paris, whose absolute length is 330 kil. (217·48 miles), that it is equivalent to 492·20 k. (305·84 miles) in going loaded, and to 465 k. (289 miles) in returning empty.

* An aid placed at each lock would gain a quarter of an hour per passage, and would cost 450 fr. per year. For a boat traveling 15 hours per day and costing 16 frs. (haulage included) a quarter of an hour is worth $\frac{16}{60} = 0·27$ frs. The expenses will then be covered when the circulation exceeds $\frac{450}{0·27} = 1667$ boats.

We might establish, according to these bases, the net minimum price of these transportations per ton per kilometre.

Going Loaded.—Proportion of the increase $\frac{492 \cdot 20}{350 \cdot 00} = 1 \cdot 406$ fr.

The net minimum price found above is 0·0031 fr. per ton per kilometre (·0927 cents per mile) loaded upon a plane without lock and without velocity, and we should, therefore, reckon for a mixed line similar to that from

| | fr. | | cts. per mile. |
|---|---|---|---|
| Mons to Paris, 1·406 × 0·0031 fr. | = 0·0044 | = | 0·1315 |
| Returning Empty.—Proportional increase $\frac{465 \cdot 20}{350 \cdot 00}$ = 1·33; the net minimum price being 0·0011 fr. (·0329 cts.), we shall have for the mixed line 1·33 × 0·0011 . . . | = 0·0014 | = | 0·0418 |
| Sum, | 0·0058 | = | 0·1733 |
| When, by a better organization of stoppages, we shall have arrived at three trips per year, the number of days of navigation may reach 275 instead of 330, whence results a new reduction of about 17 p. ct., or | 0·0010 | = | 0·0299 |
| Leaving, | 0·0048 | = | 0·1434 |
| To which we should add, for general expenses, 0·62 franc per voyage, and for 350 kilometres, or per kilometre, . . . | 0·0018 | = | 0·0538 |
| Total minimum expense, | 0·0066 | = | 0·1972 |
| At present the cost of navigation upon this line is | 0·0163 | = | 0·487 |
| Comparing it with the net minimum price found above, . . . | 0·0066 | = | 0·197 |
| We see that it is possible to still economize per ton and per kilometre, . . . | 0·097 | = | 0·290 |
| Or per ton, for a voyage of 350 kilometres, | 3·395 | = | 63·14 |
| And for a mean traffic of 1,000,000 tons upon this line, . . . | 3,395,000 fr. | = | $ 631,470 |

Such, in this view alone, is the margin yet left for lowering the net cost of navigation. We should have found it much higher, if instead of taking for a type a route remarkable for its economical management, we had considered the lines on which this day is expended 0·02 fr., 0·03 fr., and 0·04 fr. per ton per kilometre.

We may, otherwise, immediately appreciate a part of the economies to be realized in the trip from Mons to Paris; we know that a mean of the boatmen makes less than three trips per year; but in reckoning upon this maximum figure, we find, in deducting from the total number of days of navigation, . . . 275

The days of wharfage for two voyages, the last being charged to the stoppage, . . . 40

That the number of days sailing is . . . 235

Which answers to a trip of 2100 kilometres (1305 miles) only for three voyages, going and coming, and gives per day a mean trip of hardly 9 kilometres (5·59 miles).

Such a trip should be made in about 6 hours, locks and currents included, and it follows that of the 15 hours of the mean trip but two-fifths only are utilized. There are then considerable incidental expenses, which it is possible and important to annul. The material of the boating, so little utilized, far exceeds the actual need; this reservation is certainly an advantage which suffers it to live during the perfecting of its processes; but this essentially transitory resource will be destroyed in a few years, if the business of water transportation does not find, in an indispensable progress, the means of assuring its future existence upon the only solid basis, the economy of net cost.

19. In the above normal conditions, the expense of navigation with load, for reaches without velocity and locks, has been estimated per ton per kilometre at 0 0031 fr. (0·0927 cts. per mile.)

This sum may be relatively valued as follows:

| | | | |
|---|---|---|---|
| Hire of boat, | 0·0004 | | |
| Cost of equipment, maintenance, &c., | 0·0008 | | |
| | | 0·0012 | |
| Cost of hauling, | | 0·0019 | |
| | | | 0·0031 |

The towing thus constitutes the most important element of expense, that upon which improvements and ulterior reductions should be made.

The tables relative to the influence of currents show how the cost of traction is raised on the ascent, when the velocity increases. It follows that upon rivers with great circulation, the ascending navigation must be frequently stopped, even in moderate freshets. It becomes, in fact, impossible to obtain the number of animate motors which may be needed. We cannot, for a temporary issue, double or triple the number of towing horses when this number is already great. Thus we have frequent interruptions upon the lines. Upon the Sambre there are sometimes detentions of fifty days in the year due to freshets. Such irregularities are doubly regretted from the increased cost and from the uncertainty which they bring in the working of these routes. They have caused us to recognise the utility of replacing horses by mechanical motors capable of developing at a given moment a power far superior to that of the ordinary work, and many trials have been made in this direction; steam has also been applied for traction upon the Oise and Seine, between Conflans and Paris; also between Dunkirk, Lille, Valenciennes, and the Capital. The moment is, perhaps, not far distant when these isolated applications may become general. They will, we believe, have chances of success the same as common navigation, provided we keep a moderate velocity and free the motors from the loss of dearly bought time at the locks.

Machines thus applied in reaches of sufficient length, for the towage of many boats working continually in both directions, may effectually

concur in reducing the cost of navigation, and thus create new progress.

The conditions of transportation upon canals and railroads will then be quite comparable; the motor will be the same, and the ulterior improvements will react upon both kinds of routes. Regularity, continuity of service, and constancy of net cost, will then be far better assured to navigation, which will maintain the two special advantages which characterize it:

A less resistance to motion.

A more advantageous ratio of useful load to gross weight.*

Without seeking for bulky merchandise, to rival the speed of railroads, it should certainly retain by water carriage the greater part of the transportations which have a more especial need of great economy in the net cost.

20. Such seems to us should be the issue of the struggle between each of the two ways, with the resources and their appropriate elements of progress. Both will then render to the public the services which it should expect from them, and industry will find in their regular co-operation, with the varied resources of which it has need, the necessary guaranties against all ulterior monopoly.

But, if this future is possible, if the day is to come for the improvements of which the navigable routes are so susceptible, in the triple point of view of tolls, improvement in material, and progress in their system of working; it must be admitted that its actual condition is far from satisfactory, and calls for immediate action. The so rapid encroaches of the railroad upon the domain of navigable canals verify its critical position, and we need not wonder we come to a comparison of the actual net cost upon these two kinds of communication.

Upon rivers and canals these prices vary from 0·027 fr. to 0·080 fr. per ton per kilometre, which by reason of their excess in length, comes to from 0·036 fr. to 0·107 fr. (1·076 cts. to 3·199 cts. per mile).

Upon railroads the price varies from 0·036 fr. to 0·180 fr. (1·076 cts. to 5·38 cts. per mile).

In fact, some persons relying upon data generally admitted at the first opening of railways, and upon what exists at present in England, where the price never falls below 0·06 fr. (1·794 cts.), have thought that the minimum rate of 0·036 fr. (1·076 cts.), applied to these freights, was not sufficiently remunerative. According to them, with such low tolls, railroads work at a loss, and cannot hold out long; but must retire from the field and raise their tariffs. We cannot admit this opinion otherwise than as contradictory to the well established facts of the present time. The superior commission upon railroad statistics, published in 1856 documents containing the relative estimate of their working expenses. The figures relative to the Northern railroad belong to the year 1853, so that probably there would now be a diminution in the net price which they established, if we take into account the improvements which have been introduced since then.

*To transport a useful load of 225 tons, there is required 250 tons gross weight upon the canal, and 375 upon the railroad; which gives respectively the ratios 0·90 for canals and 0·60 for the railway.

With the benefit of this reservation, the expenses for one kilometre may be valued as follows:

| Nature of Expenses. | Expenses per kilometre for a train with 267 tons. | | | Expenses per ton per kilometre. | | |
|---|---|---|---|---|---|---|
| | Total. | General Expense. | Special Expense. | Total. | General Expense. | Special Expense. |
| | fr. | fr. | fr. | fr. | fr. | fr. |
| General administration, | 0·117 | 0·117 | | 0·0004 | 0·0004 | |
| Maintenance of Way, | 0·359 | 0·209 | 0·150 | 0·0014 | 0·0008 | 0·0006 |
| Working, | 0·538 | | 0.538 | 0 0020 | | 0·0020 |
| Traction, | | | | | | |
| Personel Depots, | 0·080 | | | | | |
| Fuel, 23 lbs. | 0·310 | | | | | |
| "Alimentation," | 0·017 | | | | | |
| Oiling, | 0·009 | | | | | |
| Mechanics, Stokers, | 0·127 | | | | | |
| Maintenan. of machin., | 0 253 | | | | | |
| Maintenance of cars, | 0·238 | | 1·034 | 0 0038 | | 0·0038 |
| Divers expenses, | 0·318 | 0·318 | | 0·0012 | 0·0012 | |
| Sum, | 2 366 | 0·644 | 1·722 | 0 0088 | 0·0024 | 0·0064 |
| Returning empty, half, | 1·183 | 0·322 | 0·861 | 0·0044 | 0·0012 | 0 0032 |
| Totals, | 3·549 | 0.966 | 2·583 | 0·0132 | 0·0036 | 0·0096 |
| | | | | or cts. per ton per mile. | | |
| | | | | 0·3946 | 0·1076 | 0·287 |

We must add to these expenses the interest and refunding of material used in the transportation, which amounts to 4182 fr. per kilometre for a traffic of 380,000 tons, to wit:

| | |
|---|---|
| 0·15 Merchandise, locomotive, at 115,000 fr. . . | 17,250 |
| 6·57 Wagons at 3740 fr. . . . . | 24,572 |
| Total value, . . . | 41,822 |

Which gives at 10 per cent. for interet and refunding per kil. 4182 fr.
and per ton, . . . 0·011 = 0·328 cts. per mile.

The complete price for transportation of oil by railroad may be thus established as follows:

| | | | |
|---|---|---|---|
| General expense, . . | | 0·0036 fr. = 0·1076 cts. per mile. | |
| Special expenses proportional to traffic: | | | |
| Consumption personal maintenance, | 0·0096 | | |
| Interest and refunding of material, | 0·0110 | | |
| | | ·0206 = 0·6159 | " " |
| Total, . . . | | 0·0242 = 0·7235 | " " |

We see then that at the minimum price of 0·036 fr. per ton per kilometre, there would still be in 1853 a profit of 0·0118 fr. (about 33 per cent.) for the Company. It might, without any loss, lower its tariff by 0·0206, the amount of special expenses proportional to the traffic.

At present the price of boating, deduction made for tolls, is at 0·0163 fr. upon the best worked lines, which amounts by reason of the

mean excess in length of navigable routes to 0·0220 fr. or (0·658 cts. per mile).

The railroad is working at this time in conditions the most regular, rapid, and economical. Far from being compelled to abandon the strife, it may, on the contrary, in proportion to the extension of its material draw to itself by new reductions of tariffs, a large portion of the general mass of freight.

It will be otherwise when the navigable routes, with their improvements, shall have attained the net price, above determined; the conditions of competition will then be established as follows.

Here follows a table, of which we give the general result, where allowance has been made for excess in length of navigable routes.

| | Net price per ton and per kilometre. | | | | | | |
|---|---|---|---|---|---|---|---|
| | Canals. | | | Mixed lines. | | | Railroad. |
| | Going loaded. | Return-ing em'y, | Total. | Going loaded. | Return-ing em'y. | Total. | |
| | fr. | fr. | fr. | fr. | fr. | fr. | fr. |
| General and Special Expenses. | 0 0057 | 0·0018 | 0·0065 | 0·0065 | 0·0023 | ·0088 | 0·0242 |
| | | | or cents per ton per mile. | | | | |
| | | | 0·1943 | | | 0·2631 | 0·7235 |

We shall then have

| | |
|---|---|
| By the railroads, . . . | 0·0242 |
| By mixed lines, canals and rivers, . . | 0·0083 |
| By canals only, . . . | 0 0065 |

The relative economy by the navigable routes will then be for the mixed lines: 0·0154 fr. upon 0 0242 fr., or sixty-four per cent.

For the Canals: 0 0177 fr. upon 0 0242 fr., or seventy-three per cent.

Such figures are quite imposing and bring into relief all the effective power of navigable lines, and the utility of the measures necessary to develop it.

21. The author here gives three tables, showing the principal statistical facts, relative to the Northern rivers and canals.

The first shows the variations in price of freight in the principal directions; and proves in that from Mons to Lille, and to Paris, a reduction of more than 60 per cent. in less than twenty-five years; from Charleroi towards Paris, the reduction was 30 per cent. in twelve years.

The second table indicates the principal changes not long since effected in the assessment of tolls and the developments which have followed the reductions obtained in the expense of transportation; we give the most remarkable:

The lower Scarpe, where the mean tonnage equal to 260,000 tons

before the improved works, first rose to 418,000, and has continued to increase up to the maximum of 649,000, attained in 1855.

The Deule, whose circulation has risen from 134,000 to 600,530 tons since 1818.

The canal from Mons to Condé, upon which the tonnage reduced in 1826 from 489,000 to 191,000 tons, by the making of the Belgian canal of Anthoing, has risen constantly since, and reached in 1856 the enormous sum of 1,260,000 tons.

The Canal of St. Quentin, whose traffic varied from 50,000 to 1,050,000 tons between the years 1824 and 1855.

Finally, the Sambre, which scarcely carried 30,000 tons in 1836, has realized in 1856 a maximum of 708,860.

We do not believe there exists an example of greater development of traffic so rapidly obtained. The special nature of transportations upon the Northern Canals, where oil composes the majority (about four-fifths), explains the increase, which is connected with all industrial progress, thus stimulating and receiving the reaction of their development.

The same table also proves the retrograde movement which has begun to manifest itself upon some of the principal lines: the Deule, the Scarpe, the Mons Canal, and those of the Sambre. The unusual drought of the two last years, and the recent oil discoveries of Pas-de-Calais, have exerted, without doubt, some influence upon these results, but they are especially due to the competition of the railroad, which the extension of its material renders each year more energetic and powerful.

In the third table are entered the rivers and canals, prolongations of the Northern lines towards Paris, and having for a development of 957·6 kil. (593·7 miles) the useful work of two distinct periods; the one 1844, prior to the working of the Northern railroad; the other 1855, some years after its opening.

Notwithstanding the rivalry of this new route, the useful work of the navigable routes mentioned in the table has increased in this period of eleven years; it has risen from 348,944 to 589,128 thousands of tons to one kilometre, a relative increase of 69 per cent. It represents this day a quarter of the useful work of all the rivers and canals of France for an extent scarcely equal to the twelfth of their total development of 11,225 kilometres.

The mean rate of tariffs collected in 1844, at 16·03 fr. per thousand tons at one kilometre ($4·79 per mile); since 1849 it was reduced to 12·55 fr.: notwithstanding this reduction of 22 per cent., the total product of tolls has increased from 5,594,499 to 7,378,065 fr. This fact proves the potency of this tutelary measure, which has so rapidly converted into a profit of nearly 33 per cent., the losses immediately caused by the reduction of the fees of navigation. In 1858 the tolls on returning empty were suppressed in the basin of the Aa, of Escaut, and upon the Saint-Quentin canal; there will follow from this measure a new alleviation of charges which now burthen the transportations by water.

| | |
|---|---|
| If from the total of tolls collected in 1855 and amounting to . . . | 7,378,065 fr. |
| We deduct the cost of maintenance of the different routes, which amount to . . | 1,100,000 " |
| There remains, . . . | 6,278,065 " |

This sum represents the excess of annual receipts above the expenses; the net product of navigable routes may, according to the different phases of competition, become the object of reductions, proportioned to the need of the strife. The above figures would indicate the superior limit of possible reductions, in case of necessity, if the circulation remained invariable. But as the constant effect of reductions of tariff, is to impress upon traffic a more rapid flight, it is not to be doubted, that we should by judiciously progressive abatements obtain still higher results, but we will count only upon the above figures.

The actual mean cost of the immense circulation of these navigation lines, is 16·65 fr. per thousand tons carried one kilometre. Now we have seen that even with animal motors, it would be possible to reduce the cost of navigation per ton per kilometre to 0·0066 fr. (0·1973 cts. per mile) or

| | | |
|---|---|---|
| For 1000 tons per kilometre, . . . | 6·60 fr. or $1·97 | per mile. |
| In comparing the minimum price with the actual corresponding transportation, . . . . | 16·65 fr. or 4·97 | " " |
| We have the economy to be realized by perfecting the material and working progress, . . . | 10·05 " | $3·00 |

And this independent of ulterior reductions, which would follow on the introduction of mechanical motors. Keeping to the limit of 10·05 fr. and charging it to the actual circulation, we have a product of 5,910,-736 fr., which evidently represents the inferior limit of advantages to be realized. It is certain that the tonnage will not remain stationary, but must increase from the two-fold effect of abatement of tolls, and economies in the cost of navigation.

Without losing sight of all the advantages resulting from these future developments, we see upon a basis of actual facts, that it is possible to arrive at a total reduction of 12,188,801 fr. upon the expenses of navigation, to wit:

| | |
|---|---|
| Upon tolls, . . . | 6,278,065 |
| Upon cost of transportation, . . | 5,910,736 |
| | 12,188,801 |

Now the total of expenses at the present time are as follows:

| | |
|---|---|
| Tolls, . . . . | 7,378,065 |
| Cost of Transportation, . . | 9,814,036 |
| Sum, | 17,192,101 |

Whence it follows that the realizable economy is equivalent to the *seven-tenths* of the actual expenses.

Such a result shows the value and importance of these ameliorations; the symptoms of decline evinced upon many of the most important lines

give to their research and progressive application an immediate interest for the prosperity of commerce and developments of industry.

From the past history consigned in the tables it is seen how productive are such improvements, and how quickly they are utilized by the transportation departments, responding thus with energy, by a continuous progress, to the protective measures of which it is the object. And it is hoped, that an attentive examination of them, will strengthen the opinion we have expressed upon the future in reserve for navigable routes, and shall be happy if these notes shall contribute in some respects to its accomplishment.

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## *Railway Bridge over the Rhine.*

From the Civ. Eng. and Arch. Jour., April, 1861.

The great railway bridge over the Rhine at Kehl being nearly completed, experiments to test its strength were made on it a few days since. First, the two turning parts of the bridge were manœuvred, and were found to work admirably. That of the French side, which weighs not less than 350 tons, was moved with the greatest facility by eight men, then by four, and then only by two. Afterwards, a train, consisting of five locomotives and their tenders, the locomotives alone weighing 175 tons, and the whole forming a weight of nearly $3\frac{1}{2}$ tons per metre, passed over the line, and then remained stationary on the first part of the bridge on the French side; next, a locomotive and 15 wagons filled with stone, weighing about $1\frac{3}{4}$ tons per metre, was driven over, and was subsequently stationed for a time in the middle of the bridge; in the third place, the two trains passed over side by side, and were made to stand on different fixed parts of the structure; next, two other trains, each consisting of five locomotives, were also driven over the bridge side by side, and were made to remain together some time on the turning bridges and on other portions of the structure. The weight of these two trains was 350 tons, or nearly 7 tons per metre of the line covered. Lastly, these trains were driven at full speed in contrary directions, passing each other on the bridge. Throughout the whole of these experimental trials, the deflections of the bridge did not average more than from 8 to 10 millimetres, or between a third and two-fifths of an inch; the greatest deflection was equal to four-fifths of an inch, and in this case, the part thus depressed rose again to its former level, within a quarter of an inch. The results prove that the work has been well executed.

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## *England connected with France by Railway.*

From the London Builder, No. 932.

It is said that the Emperor of the French "has at last given his sanction" to the project invented by M. Favre, a Parisian engineer, for making a railway from Calais to Dover. This gigantic project comprises a tunnel under the Channel; length 19 miles. The engineer, referring to the intrusions of water in making the Thames Tun-

nel, states that nothing of that kind can be apprehended, as the ground is mostly hard rock. The company of speculators who have taken the matter up in Paris are estimating the utmost cost of the tunnel; and the works are to be executed at a fixed price, by contractors offering every guarantee of responsibility. The French Emperor's "sanction" is doubtless very requisite, on the French side, to the French speculators who are so anxious to "annex" us; but his sanction will scarcely do on the English side, however agreeable it may be for us to escape the roll of the Channel waves in crossing to the Continent.

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## MECHANICS, PHYSICS, AND CHEMISTRY.

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*Experimental Researches to Determine the Density of Steam at all Temperatures, and to determine the Law of Expansion of Superheated Steam.* By WILLIAM FAIRBAIRN, Esq., F. R. S., and THOMAS TATE, Esq.

From the Lond. Edin. and Dub. Phil. Mag., March. 1861.

The object of these researches is to determine by direct experiment the law of the density and expansion of steam at all temperatures. Dumas determined the density of steam at 212° Fahr., but at this temperature only. Gay-Lussac and other physicists have deduced the density at other temperatures by a theoretical formula true for a perfect gas:

$$\frac{\mathrm{V}\,\mathrm{P}}{\mathrm{V}_1\,\mathrm{P}_1}=\frac{459+\mathrm{T}}{459+\mathrm{T}_1} \qquad . \qquad . \qquad (1.)$$

On the expansion of superheated steam, the only experiments are those of Mr. Siemens, which give a rate of expansion extremely high, and physicists have in this case also generally assumed the rate of expansion of a perfect gas. Experimentalists have for some time questioned the truth of these gaseous formulæ in the case of condensable vapors, and have proposed new formulæ derived from the dynamic theory of heat; but up to the present time no *reliable direct experiments* have been made to determine either of the points at issue. The authors have sought to supply the want of data on these questions by researches on the density of steam upon a new and original method.

The general features of this method consist in vaporizing a known weight of water in a globe of about 70 cubic inches capacity, and devoid of air, and observing by means of a "*saturation gauge*" the exact temperature at which the whole of the water is converted into steam. The saturation gauge, in which the novelty of the experiment consists, is essentially a double mercury column balanced upon one side by the pressure of the steam produced from the weighed portion of water, and on the other by constantly saturated steam of the same temperature. Hence when heat is applied the mercury columns remain at the same level up to the point at which the weighed portion of water is wholly vaporized; from this point the columns indicate, by a difference of level, that the steam in the globe is superheating; for superheated steam increases in pressure at a far lower rate than satu-

rated steam for equal increments of temperature. By continuing the process, and carefully measuring the difference of level of the columns, data are obtained for estimating the rate of expansion of superheated steam.

The apparatus for experiments at pressures of from 15 to 70 lbs. per square inch, consisted chiefly of a glass globe for the reception of the weighed portion of water, drawn out into a tube about 32 inches long. The globe was enclosed in a copper boiler, forming a steam-bath, by which it could be uniformly heated. The copper steam-bath was prolonged downwards by a glass tube enclosing the globe stem. To heat this tube uniformly with the steam-bath, an outer oil-bath of blown glass was employed, heated like the copper bath by gas jets. The temperatures were observed by thermometers exposed naked in the steam, but corrected for pressure. The two mercury columns forming the saturation gauge were formed in the globe stem, and between this and the outer glass tube; so long as the steam in the glass globe continued in a state of saturation, the inner column in the globe stem remained stationary, at nearly the same level as that in the outer tube. But when, in raising the temperature, the whole of the water in the globe had been evaporated and the steam had become superheated, the pressure no longer balanced that in the outer steam-bath, and, in consequence, the column in the globe stem rose, and that in the outer tube fell, the difference of level forming a measure of the expansion of the steam. Observations of the levels of the columns were made by means of a cathetometer at different temperatures, up to 10° or 20° above the saturation point; and the maximum temperature of saturation was, for reasons developed by the experiments, deduced from a point at which the steam was decidedly superheated.

The results of the experiments, which in the paper are given in detail, show that the density of saturated steam at all temperatures, above as well as below 212°, is invariably greater than that derived from the gaseous laws.

The apparatus for the experiments at pressures below that of the atmosphere was considerably modified; and the condition of the steam was determined by comparing the column which it supported with that of a barometer. The results of these experiments reduced in the same way, are extremely consistent.

As the authors propose to extend their experiments to steam of a very high pressure, and to institute a distinct series on the law of expansion of superheated steam, they have not at present given any elaborate generalizations of their results. The following formulæ, however, represent the relations of specific volume and pressure of saturated steam, as determined in their experiments, with much exactness.

Let V be the specific volume of saturated steam, at the pressure P, measured by a column of mercury in inches; then

$$\text{V} = 25{\cdot}62 + \frac{49513}{\text{P} + {\cdot}72} \qquad (2.)$$

$$\text{P} = \frac{49513}{\text{V} - 25{\cdot}62} - 0{\cdot}72. \qquad (3.)$$

In regard to the rate of expansion of superheated steam, the experiments distinctly show that, for temperatures within about ten degrees of the saturation point, the rate of expansion greatly exceeds that of air, whereas at higher temperatures the rate of expansion approaches very near that of air. Thus in experiment 6, in which the maximum temperature of saturation is 174°·92, the co-efficient of expansion between 174°·92 and 180° is $\frac{1}{160}$, or three times that of air; whereas between 180° and 200° the co-efficient is very nearly the same as that of air (steam $=\frac{1}{537}$, air $=\frac{1}{539}$), and so on in other cases. The mean co-efficient of expansion at zero of temperature from seven experiments below the pressure of the atmosphere, and calculated from a point several degrees above that of saturation, is $\frac{1}{433}$, whereas for air it is $\frac{1}{459}$. Hence it would appear that for some degrees above the saturation point the steam is not decidedly in an aëriform state, or, in other words, that it is watery, containing floating vesicles of unvaporized water.

TABLE *of Results, Showing the Relation of Density, Pressure, and Temperature of Saturated Steam.*

| Number of experiment. | Pressure in lbs. per sq. inch. | Pressure in inches of mercury. | Maximum temp. of saturation. Fah. | Specific Volume. From experiment. | Specific Volume. By formula (2). | Proportional error of formula (2). |
|---|---|---|---|---|---|---|
| | | | ° | | | |
| 1 | 2·6 | 5·35 | 136·77 | 8266 | 8183 | $+\frac{1}{100}$ |
| 2 | 4·3 | 8·62 | 155·33 | 5326 | 5326 | 0 |
| 3 | 4·7 | 9·45 | 159·36 | 4914 | 4900 | $-\frac{1}{350}$ |
| 4 | 6·2 | 12·47 | 170·92 | 3717 | 3766 | $+\frac{1}{74}$ |
| 5 | 6·3 | 12·61 | 171·48 | 3710 | 3740 | $+\frac{1}{123}$ |
| 6 | 6·8 | 13·62 | 174·92 | 3433 | 3478 | $+\frac{1}{76}$ |
| 7 | 8·0 | 16·01 | 182·30 | 3046 | 2985 | $-\frac{1}{50}$ |
| 8 | 9·1 | 18·36 | 188·30 | 2620 | 2620 | 0 |
| 9 | 11·3 | 22·88 | 198·78 | 2146 | 2124 | $-\frac{1}{97}$ |
| 1′ | 26·5 | 53·61 | 242·90 | 941 | 937 | $-\frac{1}{235}$ |
| 2′ | 27·4 | 55·52 | 244·82 | 906 | 906 | 0 |
| 3′ | 27·6 | 55·89 | 245·22 | 891 | 900 | $+\frac{1}{100}$ |
| 4′ | 33·1 | 66·84 | 255·50 | 758 | 758 | 0 |
| 5′ | 37·8 | 76·20 | 263·14 | 648 | 669 | $+\frac{1}{32}$ |
| 6′ | 40·3 | 81·53 | 267·21 | 634 | 628 | $-\frac{1}{100}$ |
| 7′ | 41·7 | 81·20 | 269·20 | 604 | 608 | $+\frac{1}{150}$ |
| 8′ | 45·7 | 92·23 | 274·76 | 583 | 562 | $-\frac{1}{29}$ |
| 9′ | 49·4 | 99·60 | 279·42 | 514 | 519 | $+\frac{1}{100}$ |
| 11′ | 51·7 | 101·54 | 282·58 | 496 | 496 | 0 |
| 12′ | 55·9 | 112·78 | 287·25 | 457 | 461 | $+\frac{1}{114}$ |
| 13′ | 60·6 | 122·25 | 292·53 | 432 | 428 | $-\frac{1}{105}$ |
| 14′ | 56·7 | 114·25 | 288·25 | 448 | 456 | $+\frac{1}{56}$ |

Adopting the notation previously employed, and putting $r$ for the

rate or co-efficient of expansion of an elastic fluid at $t_1$ temperature we find

$$r = \frac{1}{\varepsilon_1 + t_1} = \frac{\frac{V_2 p_2}{V_1 p_1} - 1}{t_2 - t_1}, \qquad (4.)$$

where $\frac{1}{\varepsilon_1}$ = the rate of expansion at zero of temperature. In the case of air, $\varepsilon_1 = 459$.

The following Table gives the value of the co-efficient of expansion of superheated steam taken at different intervals of temperature from the maximum temperature of saturation.

| Number of experiment. | Maximum temperature of saturation. | Temperatures between which the expansion is taken. | | Co-efficient of expansion of superheated steam. | Co-efficient of expansion of air. |
|---|---|---|---|---|---|
| | ° | ° | ° | | |
| 1 | 136·77 | 140 | 170 | $\frac{1}{593}$ | $\frac{1}{599}$ |
| 2 | 155·33 | 160 | 190 | $\frac{1}{556}$ | $\frac{1}{619}$ |
| 3 | 159·36 | 159·36 | 170·2 | $\frac{1}{150}$ | $\frac{1}{618}$ |
| | | 170·2 | 209·9 | $\frac{1}{624}$ | $\frac{1}{629}$ |
| 5 | 171·48 | 171·48 | 180 | $\frac{1}{200}$ | $\frac{1}{630}$ |
| | | 180 | 200 | $\frac{1}{604}$ | $\frac{1}{639}$ |
| 6 | 174·92 | 174·92 | 180 | $\frac{1}{190}$ | $\frac{1}{634}$ |
| | | 180 | 200 | $\frac{1}{637}$ | $\frac{1}{639}$ |
| 7 | 182·30 | 182·3 | 186 | $\frac{1}{230}$ | $\frac{1}{641}$ |
| | | 186 | 209 5 | $\frac{1}{630}$ | $\frac{1}{645}$ |
| 8 | 188·30 | 191 | 211 | $\frac{1}{604}$ | $\frac{1}{650}$ |
| 1′ | 242·9 | 243 | 249 | $\frac{1}{517}$ | $\frac{1}{702}$ |
| 4′ | 255·5 | 257 | 259 | $\frac{1}{392}$ | $\frac{1}{716}$ |
| | | 257 | 264 | $\frac{1}{600}$ | $\frac{1}{716}$ |
| 6′ | 267·21 | 268 | 271 | $\frac{1}{210}$ | $\frac{1}{727}$ |
| | | 271 | 279 | $\frac{1}{640}$ | $\frac{1}{730}$ |
| 7′ | 269·2 | 271 | 273 | $\frac{1}{232}$ | $\frac{1}{730}$ |
| | | 273 | 279 | $\frac{1}{551}$ | $\frac{1}{733}$ |
| 9′ | 279·42 | 283 | 285 | $\frac{1}{298}$ | $\frac{1}{742}$ |
| | | 285 | 289 | $\frac{1}{533}$ | $\frac{1}{744}$ |
| 13′ | 292·53 | 297 | 299 | $\frac{1}{281}$ | $\frac{1}{756}$ |
| | | 299 | 302 | $\frac{1}{638}$ | $\frac{1}{758}$ |

Hence it appears, that as the steam becomes more and more superheated, the co-efficient of expansion approaches that of a perfect gas. The authors hope that these experiments may be continued, and that the results obtained at greatly increased pressures will prove as important as those already arrived at.

For the Journal of the Franklin Institute.

*The Manufacture of Cast Iron Pipes.* By Ed. Brandt, Esq.

(Continued from page 333.)

Secondly.—I will now consider the defects of "green sand moulds" and "green sand cores." This class of pipes are cast upon a level, and are run from each end.

The objects in using green sand are substantially these, viz: The saving of straw, the labor of making the ropes and putting them on the core bar, and drying the cores. If the cores are properly made there is much less risk of forming blisters; indeed, the ratio of pipes saved by this method far exceeds the "loam core inclined pipe." But this system has some drawbacks, and I believe that it is found, upon the whole, to be but little cheaper than the loam core in point of labor; but, as I before stated, it is a safer method than the loam core and dry sand mould.

To use green sand cores, the following conditions must be complied with:

The core sand must be very open or coarse, and used as dry as practicable.

The cores cannot be "sleeked," nor can they be blackened.

The sand must be put on the core bars by hand as lightly as possible, in order to adhere to the bar, and finished by sifting sand upon them as a finishing coat.

They require pouring very fast with sharp iron. These conditions are absolutely necessary, and if not complied with, will result in the blistering of the surface, or an admixture of sand and iron through the pipe. To make good pipes by this method, it is necessary to pour them quick and with sharp metal. To do this with "green sand cores" will be likely to produce the following results, viz: 1st. The core sand is coarse and dryish, and not sleeked, and in consequence, the hot iron will wash off a great amount of sand that is just sticking fast enough not to fall off, and will carry it into the pipes. And further, from the core not being sleeked or blacked, and being coarse, the hot iron will enter freely into the pores of the sand, which will fasten a heavy coat of coarse sand over the surface of the inside of the pipe. 2d. The pipe must be poured up quick with hot iron, so as to put on a sharp strain, to prevent blisters, and as the cores are soft they strain along the bottom; and as the sand of the core is pressed on the core bars by the fingers, there are frequently numerous small soft places which will strain most, thereby causing the inside of the pipe to be very uneven. The spring in the core bar is about the same as in a loam core.

The running surface is very great, about 150 ins. area; but this evil is modified to a great extent by running the pipe from each end. It being cast horizontally allows the dull iron and dirt to rise to the top of the mould, causing a liability of the pipes to blister or cold shut upon its upper surface.

It is evident that this class of pipes, like those with loam cores, have a *soft side;* the top is liable to be thinnest, and is cast with the dullest iron, and into this side is washed all the loose particles of sand that are washed from the unsleeked core; the light pressure which is put

upon the metal in the top of the pipe (probably not more than 2 lbs. to the inch.) and the large running surface unite to cause it to be blistered and "cold shut," as the amount of pressure is insufficient to press the iron compactly together along its whole length, when it is in the condition above described. Why not increase the pressure on the top of the pipe? If the pressure is increased on the top of the pipe, you increase it also on the bottom, and it is much more effective on the bottom, because the iron is hotter and more fluid, and thereby causes a still greater strain upon the bottom of the core, which being soft gives way and renders the inside of the pipe very rough and uneven, thereby causing a serious obstruction to the passage of water. The service obtained from this class of pipes, for the above reasons, will be much less than from those of the same diameter with smooth bore.

I have shown the difficulties to be met with in green sand moulding to be of a character which may lead to great doubts of the expediency of running so great risk as must needs be in using castings of that character. I have considered these difficulties under the following heads, viz:—

I. Their tendency to uneven thickness.

II. Their tendency to blow or blister.

III. Their tendency to be very weak upon the top or cope side, and the causes which led to the first of these, viz: their tendency to uneven thickness, being again subdivided in the following order, viz:—

1st. Spring of the core bar.

2d. Raising of the loam of the core upon the bar.

3d. Manner of securing the core.

4th. The necessity of setting them out of centre.

5th. Clamping.

Thirdly.—I will now endeavor to show that these evils may be avoided by casting vertically.

1st. "Spring of the core bar." The core bar being placed in a vertical position cannot spring, as there can be no lift upon it or tendency to move in any direction.

2d. "Raising of the loam of the core upon the bar." The loam upon the bar, however loose, must be equal all round, the pressure of the iron being the same upon all sides, at all times during the "pour."

3d. "The manner of securing the core." As there is no tendency for the bar to move from the position in which it is placed, it only remains for the mechanic to make such arrangements as to insure its centering properly, which is done by having the lower end of the core bar turned to fit a corresponding opening or seat, which effectually prevents its getting out of centre, while the upper end being in sight can be easily adjusted and set to a gauge. Hence, there is no more excuse for the core being out of centre than there is for the pipe being improperly made from any other cause. It, however, may be of uneven thickness, though the cores may be centered properly, should the mould be crooked; but this, like the above, is not a natural difficulty, but is the result of carelessness or negligence of inexperienced operators. An effectual check may be put upon that objection by requiring them to be within certain limits, and rejecting any that should

be beyond them; and as there are no natural or mechanical difficulties to surmount, proper care would soon rectify it.

4th. "The necessity of setting the core out of centre." As the cores have no tendency to change their position whilst the pipe is being cast, as a consequence there can be no necessity for setting them out of centre in order to insure an average pipe; it would indeed have an opposite result.

5th. "Clamping." Inasmuch as the flasks are clamped before they are "rammed," no difficulty from this cause can arise.

II. I next consider their inability to "blow" or "blister."

1st. In casting vertically, the hot iron is run on all sides of the core at the same time, and consequently, there is no point at which the iron is in a "duller" state than in another.

2d. If there should be, the "dull" iron would naturally rise on top, and would be in a position to catch the hot falling iron; and as a stream of fluid iron continuing to fall for a short time upon cold iron is capable of bringing it into a fluid state, it must necessarily have the effect of keeping the top surface of "the cast" in the "sharpest" possible condition.

3d. The pressure is run up very quick, and the running surface very small. This effectually avoids blisters by pressing the iron compactly whilst it is "sharp," and holding it there so firmly that the gas from the core more readily makes its way to and out of the core-bar than it can displace the iron in the mould.

It will be seen by comparison that the running surface of a 6-inch pipe, cast vertically, is about 10 square inches, and the running surface of a pipe of the same diameter, cast at an angle of about 10°, will be about $4\frac{1}{2}$ times that amount, and being only about two feet from the lowest to the highest point; whereas, the vertical pipe is its length (say 9 feet), but one-third of the inclined pipe will have an elliptical running surface of six and-a-half inches diameter one way, and three feet one inch the other; this surface will vary in width from one-half to one and-a-half inches, giving a running surface of 72 ins. area. Thus, it will be seen that the part of the pipe which is usually blistered, is filled more than seven times as quick in a vertical mould than it is in an inclined one, *i. e.*, supposing the two pipes to be of the same length and diameter, and cast in the same period of time. And further, I repeat, that instead of having the dull iron all driven to one side of the pipe, you have hot iron dropping into the cast upon all sides of the running surface, varying from 9 feet, or the length of the pipe, to 0. Again, when the vertical pipe is cast there will be from 12 to 15 pounds pressure per inch in the middle of the length of the pipe (9 feet), whilst the inclined cast has but 3 to 5 lbs. per inch.

III. "The tendency to weakness on the cope side." There being no cope side, this weakness is entirely avoided; in other words, there is no particular point of weakness in a vertical cast pipe.

"Cold Shuts." The running surface in a vertical cast pipe is so small, that the hot iron falling into it renders the liability to "cold shut" almost an impossibility. The mould and core are of such a na-

ture that if properly made and thoroughly dried, they will stand the passage of a current of iron as nearly perfect as sand moulds can do. There is little or no straining either in mould or core, and this is an important feature, for all strains are a total loss of so much iron that is taken away from other parts of the pipe.

They are cleaner. In casting the pipes the iron is poured into a basin that surmounts the top of the flask and surrounds the core, the runners are in the bottom of this basin, which is instantly poured full, and kept in that state until the pipe is "up," whilst the dirt which gets in this basin (if any) from the ladle, will float there and cannot get into the pipe. Yet there is dirt or impurities constantly giving out from the iron, when in a fluid state, of some manufacturers more than in others; but all gives off more whilst in motion than when at rest; thus all castings will have some dirt in them, however carefully the ladle may be skimmed, because the dirt continues to rise so long as the iron is in a fluid state. In pipes the dirt assumes various forms or positions, depending wholly upon circumstances. In those of large diameters, cast vertically, when the thickness is great, it will collect in lumps and float towards the top, where it is occasionally intercepted and forms a soft place, which will usually "sweat" under pressure, and consequently may be readily found in the press. But in those of small diameters cast in the same manner, so much of the running surface is covered by the runners, and the cast is brought up so quickly, that the dirt has but little time or opportunity to separate from the iron and collect in a body, except in cases where the iron is *very* dirty, when it will rise towards the top, in which case the proof pressure will find it. The dirt here spoken of is that which separates from the iron after it has passed the runners into the mould, and is about the same in quantity in any kind of mould, it depending upon the weight of iron poured and the quality of iron used.

In conclusion, I would remark, that the superiority of the vertical over the horizontally cast pipes, consists principally in the following advantages:

1st. There is no lift to the core, or tendency for it to move from the position it is placed in.

2d. The small running surface.

3d. The rapidity with which the pressure is put upon the iron whilst it is in a fluid state.

4th. The iron falling directly to its place with all the velocity and force of its gravity, thereby thoroughly mixing the hot iron with the whole running surface.

5th. The firmness of the mould.

6th. The facilities for making the casting clean.

7th. The ability to increase the length of the pipes without endangering the perfection of the casting, thereby saving in weight of casting, cost of labor, and material in laying, to which add the saving of lead joints, in itself an item of importance.

In reference to the transverse strength of pipes of small diameter, I herewith submit a tabular description, taken from experiments made at the Warren Foundry, Philipsburgh, New Jersey.

Trial A.—Cast Vertically.

Pipe 4 inches inside diameter, $\frac{3}{8}$ths of an inch thick, weighing 201 lbs., 12 feet long; supported at the extreme ends. Weight applied on slings three feet from each end. Points of deflection taken three feet from each end and centre.

| Weight in lbs. | Hub End. | | Middle. | | Spigot End. | |
|---|---|---|---|---|---|---|
| | Partial deflection. | Whole deflection. | Partial deflection. | Whole deflection. | Partial deflection. | Whole deflection. |
| 1000 | ·25 | ·25 | ·31 | ·31 | ·25 | ·25 |
| 2000 | ·12 | ·37 | ·25 | ·56 | ·18 | ·43 |
| 3000 | ·31 | ·68 | ·37 | ·93 | ·25 | ·68 |
| 4000 | ·32 | 1·00 | ·38 | 1·31 | ·28 | ·96 |
| 5000 | ·31 | 1·31 | .50 | 1·81 | .29 | 1·25 |
| 5500 | ·19 | 1·50 | ·25 | 2·06 | ·18 | 1·43 |
| 6000 | ·12 | 1·62 | ·19 | 2·25 | ·13 | 1·56 |
| 6225 | Broke in two places, 5 inches in from points of weight. | | | | | |

Trial B.—Cast Vertically.

Pipe 4 inches in diameter, $\frac{3}{8}$ths of an inch thick, 12 feet long, weighing 202 lbs.; supported at the extreme ends, and weights applied in the centre, suspended by a sling. Points of deflection taken three feet from the ends and centre.

| Weight in lbs. | Hub End. | | Middle. | | Spigot End. | |
|---|---|---|---|---|---|---|
| | Partial deflection. | Whole deflection. | Partial deflection. | Whole deflection. | Partial deflection. | Whole deflection. |
| 1000 | ·18 | ·18 | ·31 | ·31 | ·18 | ·18 |
| 1500 | ·19 | ·37 | ·25 | ·56 | ·19 | ·37 |
| 2000 | ·19 | ·56 | ·31 | ·87 | ·19 | ·56 |
| 2500 | ·19 | ·75 | ·25 | 1·12 | ·19 | ·75 |
| 3000 | ·25 | 1·00 | ·31 | 1·43 | ·28 | 1·03 |
| 3250 | ·06 | 1·06 | ·19 | 1·62 | ·03 | 1·06 |
| 3375 | ·09 | 1·15 | ·06 | 1·68 | ·09 | 1·15 |
| 3500 | ·03 | 1·18 | ·13 | 1·81 | ·01 | 1·16 |
| 3625 | ·07 | 1·25 | ·06 | 1·87 | ·05 | 1·21 |
| 3750 | ·06 | 1·31 | ·13 | 2·00 | ·07 | 1·28 |
| 3850 | Broke 12 inches from centre, towards the hub. | | | | | |

Trial C.—Cast Vertically.

Pipe 6 inches in diameter, $\frac{3}{8}$ths of an inch thick, 12 feet long, weighing 340 lbs.; supported at the extreme ends, and weights applied on slings placed 3 feet from each end. Points of deflection taken 3 feet from each end and centre.

| Weight in lbs. | Hub End. | | Middle. | | Spigot End. | |
|---|---|---|---|---|---|---|
| | Partial deflection. | Whole deflection. | Partial deflection. | Whole deflection. | Partial deflection. | Whole deflection. |
| 1000 | ·03 | ·03 | ·03 | ·03 | ·03 | ·03 |
| 2000 | ·09 | ·12 | ·15 | ·18 | ·09 | ·12 |
| 3000 | ·09 | ·21 | ·13 | ·31 | ·09 | ·21 |
| 4000 | ·07 | ·28 | ·03 | ·34 | ·07 | ·28 |
| 5000 | ·06 | ·34 | .09 | ·43 | ·03 | ·31 |
| 6000 | ·09 | ·43 | ·16 | ·53 | ·06 | ·37 |
| 7000 | ·07 | ·50 | ·10 | ·69 | ·06 | ·43 |
| 8000 | ·00 | ·50 | ·06 | ·75 | ·07 | ·50 |
| 9000 | ·09 | ·59 | ·06 | ·81 | ·06 | ·56 |
| 10000 | ·09 | ·68 | ·09 | ·90 | ·06 | ·62 |
| 11000 | ·13 | ·81 | ·13 | 1·03 | ·10 | ·72 |
| 12000 | ·03 | ·84 | ·15 | 1·18 | ·03 | ·75 |
| 12900 | Broke at the points of weight. | | | | | |

### Trial D.—Cast Vertically.

Pipe 6 inches in diameter, ⅜ths of an inch thick, 12 feet long, weighing 314 lbs; supported at the extreme ends, and weight applied on slings at the centre of length. Deflection taken at points three feet from each end and centre.

| Weight in lbs. | Hub End. | | Middle. | | Spigot End. | |
|---|---|---|---|---|---|---|
| | Partial deflection. | Whole deflection. | Partial deflection. | Whole deflection. | Partial deflection. | Whole deflection. |
| 1000 | ·12 | ·12 | ·12 | ·12 | ·06 | ·06 |
| 2000 | ·06 | ·18 | ·19 | ·31 | ·12 | ·18 |
| 3000 | ·13 | ·31 | ·06 | ·37 | ·07 | ·25 |
| 4000 | ·06 | ·37 | ·13 | ·50 | ·06 | ·31 |
| 4500 | ·06 | ·43 | ·09 | ·59 | ·06 | ·37 |
| 5000 | ·03 | ·46 | ·06 | ·65 | ·06 | ·43 |
| 5500 | ·10 | ·56 | ·10 | ·75 | ·07 | ·50 |
| 6000 | ·06 | ·62 | ·06 | ·81 | ·06 | ·56 |
| 6500 | ·06 | ·68 | ·12 | ·93 | ·06 | ·62 |
| 7000 | ·07 | ·75 | ·13 | 1·06 | ·06 | ·68 |
| 7500 | ·06 | ·81 | ·06 | 1·12 | ·03 | ·71 |
| 8000 | ·06 | ·87 | ·06 | 1·18 | ·04 | ·75 |
| 8500 | ·06 | ·93 | ·03 | 1·21 | ·08 | ·83 |
| 9000 | ·07 | 1·00 | ·22 | 1·43 | ·07 | ·90 |
| 9115 | Broke in the centre. | | | | | |

### Trial E.—Cast Horizontally.

Pipe cast in "green sand," 6 inches in diameter, 9-16ths of an inch thick, 9 feet long, weighing 354 lbs.; supported at the extreme ends, and weight applied on slings in the centre. Deflection taken at centre of length.

| Weight in lbs. | Middle. | | Weight in lbs. | Middle. | |
|---|---|---|---|---|---|
| | Partial deflection. | Whole deflection. | | Partial deflection. | Whole deflection. |
| 1000 | ·03 | ·03 | 7000 | ·03 | ·28 |
| 2000 | ·03 | ·06 | 8000 | ·06 | ·34 |
| 3000 | ·06 | ·12 | 9000 | ·04 | ·38 |
| 4000 | ·03 | ·15 | 10000 | ·02 | ·40 |
| 5000 | ·07 | ·22 | 11000 | ·13 | ·53 |
| 6000 | ·03 | ·25 | 11700 | Broke in the centre. | |

### Trial H.—Cast Vertically.

Pipe 6 inches in diameter, ⅜ths of an inch thick, 9 feet long, weighing 302 lbs.; supported at the extreme ends, and weight applied at the centre. Deflection taken at same point.

| Weight in lbs. | Middle. | | Weight in lbs. | Middle. | |
|---|---|---|---|---|---|
| | Partial deflection. | Whole deflection. | | Partial deflection. | Whole deflection. |
| 1000 | ·03 | ·03 | 8000 | ·10 | ·56 |
| 2000 | ·06 | ·09 | 9000 | ·09 | ·65 |
| 3000 | ·10 | ·19 | 10000 | ·10 | ·75 |
| 4000 | ·06 | ·25 | 11000 | ·03 | ·78 |
| 5000 | ·03 | .28 | 12000 | ·03 | ·81 |
| 6000 | ·10 | ·38 | 13000 | ·07 | ·88 |
| 7000 | ·08 | ·46 | 13950 | Broke in the centre. | |

Trials F and G were upon condemned pipes. F broke with a weight of 8400 lbs., and was very defective at the point of rupture. G broke with a weight of 8325 lbs.; the casting was of poor iron and cast with wet core, having caused a boiling surface.

The tensile strength of a pipe 30 inches in diameter, cast at the Florence Foundry, N. J., and afterwards broken up, was tried at the proving machine of the West Point Foundry, and it was found equal to 22,133 lbs. per square inch. This might be considered an average specimen of the iron used in the American foundries for pipe castings.

Specimens taken from pipes cast at the Phœnix Iron Works, Glasgow, Scotland, were sent to the South Boston Foundry, Messrs. Alger & Co., and tried by their proving machine with the following results:

| | |
|---|---|
| Piece of 30-inch pipe, . | 22,978 lbs. per sq. in. |
| " 20-inch " . | 24,222 " " |
| " 20-inch " . | 19,493 " " |
| " 12-inch " . | 21,290 " " |

For the Journal of the Franklin Institute.

## *Account of Experiments upon the Advantage of Throttling Steam.*

Mr. J. Bermingham, Chief Engineer of the *Golden Age*, made a series of experiments upon that vessel on the 19th of February last, for the purpose of ascertaining the advantage, if any, to be gained by throttling the steam. The vessel is fitted with one vertical beam engine. Diameter of cylinder, $83\frac{1}{4}$ inches; stroke of piston, 12 feet. The boilers are of the drop-flue kind, two in number, and were made in the year 1852.

The table, as given below, was compiled from six sets of indicator diagrams, taken and worked out with the utmost care.

| Engine fitted with Stevens' cut-off. | Cut-off at $\frac{1}{2}\frac{3}{4}$ of the stroke. Throttle wide open. | Cut-off at $\frac{1}{2}\frac{3}{4}$ of the stroke. Throttle $\frac{1}{4}$ open. |
|---|---|---|
| Pressure of steam in boilers, pounds, . | 8·5 | 15·1 |
| Temperature of sea water, . | 86° | 86° |
| Temperature of water discharged from condenser, | 115° | 114° |
| Revolutions of wheels per minute, . | 11·25 | 11·14 |
| Indicated horse-power developed by engine, | 627·5 | 610·9 |
| Cubic feet of atmospheric steam used per each horse-power per minute, . . | 10·87 | 10·97 |
| Cubic feet of atmospheric steam used per each revolution of wheel, . . | 606·8 | 601·82 |
| Steam used per each horse-power per hour, pounds, | 24·15 | 24·25 |
| Steam passing the cylinder per hour, pounds, | 15055 | 14787 |
| Coal used per horse-power per hour, pounds, . | 3·9 | 3·9 |
| Water evaporated per pound of coal, pounds, | 6·01 | 6·01 |
| Mean pressure on piston, pounds, . | 14·1 | 13·9 |
| Speed of vessel, miles, . . | 9 7 | 9·657 |

Temperature of steam entering cylinder, about 275° or 285°
" gases escaping up steam chimney, about 525°
Economy in favor of open throttle, as per results above, $\frac{8}{10}$ths of 1 per cent.

During both trials, the injection valve had exactly the same opening, and it is to be observed that the sea water was precisely of the same temperature.

NOTE.—The dimensions of the *Golden Age* are as follows:—Length on deck, 270 ft. Breadth of beam, 42 ft. Depth of hold, 16 ft. 4 ins. Do., to spar deck, 24 ft. 4 ins. Draft of water at load line, 17 ft. Diameter of water wheels overboards, 34 ft. 6 ins.

E. B.

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## *Cleaning of Platinum.*

From the Lond. Chemical News, No. 51.

SIR,—A remarkably rapid and perfect method of cleaning platinum apparatus consists in gently rubbing upon the dirty metal a small lump of sodium-amalgam. Sodium has the curious property of lending to mercury the power of "wetting" platinum in so complete a manner that the positive capillarity between platinum and an amalgam containing even only a few per cent. of sodium appears to be as great as that between mercury and zinc, with this important difference, however,—in the former case the "wetted" metal does not suffer the least trace of amalgamation. Even when foreign metals, such as lead, tin, zinc, silver, are purposely added to the soda-amalgam, the platinum surface suffers no disintegration.

When the amalgam has been rubbed on with a cloth, until the whole surface is brilliantly metallic, water is applied, which oxidizes the sodium and allows the cohesion of mercury to assert itself. On wiping the mercury off, the platinum surface is left in an admirable condition for the burnisher. I suppose the sodium to act here chiefly as a diluent, diminishing thereby the cohesion of the mercury and allowing the adhesion between that metal and the platinum to predominate,—a result which is certainly assisted by the mercury enabling the sodium to offer a clean surface to the platinum, and so allowing the specific adhesion between the two latter metals to be exhibited. F. G.

Laboratory, University of Edinburgh.

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## *Gas-Lighting.*

It has been often said that gas-lighting was unknown in the year 1800. Hydrogen gas was used for illuminating in 1733. Clayton's demonstration of gas-lighting by coal gas was before the public in 1737. Dr. Watson produced and burned coal gas in 1767. Murdoch lighted his house at Redruth, Cornwall, with gas, in 1792, and made an extensive gas apparatus at the Soho Works, in 1798, the works being illuminated at the declaration of peace, in 1802. Pall-mall was lighted with gas, made under Windsor's patent in 1804.—*Lond. Engineer, No.* 254.

## *Saline Strength of the Sea.*

From the Lond. Engineer, No. 245.

A new subject of research, which had hitherto been but cursorily touched upon, viz: the amount of salt contained in the sea under different latitudes, has just received a considerable degree of development through the labors of M. R. Thomassy, who, in the pursuit of his object, has crossed the Atlantic several times in all directions, thus performing a voyage of nearly 12,000 leagues. The determination of the degree to which sea water is impregnated with salt in different places is important, both because it exercises an influence over the existence and propagation of various marine species, and because it may furnish mariners with useful indications of certain contingencies worthy of attention. In northern latitudes, for instance, a diminution in the degree of saturation will warn the navigator of the breaking up of ice in the polar regions, or else it will inform him of the proximity of land. For his observations, M. Thomassy has employed the areometer of Beaume, the most convenient instrument of all, since it merely consists of a glass ball with a graduated tube attached to it, which, by sinking more or less in the liquid to be experimented on, denotes its degree of saturation. Assuming this instrument to be so graduated as to denote the liquid it displaces in sinking by thousandth parts to every tenth of a degree, M. Thomassy's experiments show that the salt contained in the water of the Atlantic, taken at the surface, and at a distance from islands, continents, and the ice of the polar regions, is represented by a minimum of 4°, which, under the evaporating influence of the trade winds and a tropical sun, may rise to 4·40°. At the mouths of rivers subject to the tides of the ocean, the areometer, or halometer, as we may call it in the present instance, marks 3° at high tide, the ebb making it fall at least 1° (the more the instrument sinks the less is the salt contained in the water). Along the coasts subject to the influence of rivers, the instrument, according as there is flow or ebb, oscillates between 2·40° and 3·50°, but may rise to 3·80° in southern latitudes. The Gulf Stream marks 3·90. Those who desire further particulars on this interesting subject may consult M. Thomassy's paper in the *Bulletin de la Société Geologique de France*, vol. xvii., p. 666.

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## *On the Impossibility of Puddling Iron which contains Copper.*

By Dr. C. List.

From the Lond. Chemical News, No. 68.

It has been stated as a matter of belief among practical iron workers in Germany, that pig iron which contains copper cannot be puddled; assertions having even been made, that when one puddler wishes to annoy another he will sometimes throw a bit of copper—a small coin for example—into the furnace, so that the iron cannot be made to "rise."

Without giving full credence, as yet, to this statement, Dr. List

mentions that he has observed two instances which go to prove that it may be correct. In the case which he has more particularly described, none of the phenomena which ordinarily occur when iron is puddled appeared. Some 400 lbs. of pig iron having been placed in the furnace, were melted in the course of half-an-hour, at which time a sample taken from the molten mass was perfectly white, but the usual evolution of carbonic oxide, and consequent swelling or "rising" up of the mass of scales, &c., about the iron, did not ensue. On the contrary, by the time that the balling together of the iron should have commenced, it was evident that the charge could not be worked off; it was therefore removed from the furnace, after having remained there about three-quarters of an hour. As the melted metal was flowing out it emitted numerous beautiful blue sparks, which were also produced when the metal in the furnace was stirred. The sparks were regarded by the workmen as an indication that the iron contained copper.

The amount of metallic iron which remained weighed 240 lbs., 160 lbs. having been lost in the scales and slag. Analyses (for details of which see the original memoir) were made of the original pig iron, (I.); of the sample taken, as previously mentioned, from the melted iron, as it lay beneath the scales (II.); and of the iron after it had been removed from the furnace (III.)

| | I. | II. | III. |
|---|---|---|---|
| Silicon, | 1·32 | 0·29 | — |
| Sulphur, | 0·28 | — | 0·20 |
| Manganese, | 3·56 | — | 0·48 |
| Copper, | 0·35 | 0·38 | 0·57 |

It was evident, therefore, that the 400 lbs. of pig iron used did really contain nearly a pound and a half of copper. It appears, moreover, that copper cannot be removed from iron by puddling. Calculating how much copper ought to be left in the iron which was finally removed from the furnace, in case none had been lost in the slag, it is found that there should be 0·58 per cent., almost exactly the quantity which was obtained in analysis No. III.—*Dingler's Polytechnisches Journal.*

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## *Cæsium.—A New Alkali Metal.*

At the last meeting of the Chemical Society, Dr. Roscoe gave a short account of Professors Kirchhoff and Bunsen's spectrum researches, and mentioned that the new alkali metal which they had discovered by that means had been named *Cæsium*, from the Latin word *cæsius*, signifying grayish-blue, that being the tint of the two spectral lines which it shows. By working with the residues from twenty tons of the mineral waters of Kreuznach, Professor Bunsen had succeeded in obtaining about 250 grains of the platinum salt of the new metal. Cæsium is closely allied to potassium in its chemical characters, the chief point of difference being the solubility of its nitrate in alcohol. Its equivalent number is 117,—exactly three times that of potassium. —*Chemical News, No. 57.*

For the Journal of the Franklin Institute.

*Strength of Cast Iron and Wrought Iron Pillars:* A series of Tables deduced from several of Mr. Eaton Hodgkinson's Formulæ, showing the Breaking Weight and Safe Weight of Cast Iron and Wrought Iron Uniform Cylindrical Pillars. By Wm. Bryson, Civ. Eng.

(Continued from page 310.)

Comparative table representing the strength of long flexible pillars of timber and iron to sustain a pressure in the direction of their length, both ends being flat and firmly fixed, and the height of the pillars exceeding 30 times their diameter.

This table shows the calculated breaking weight of solid square pillars of Red Deal and Dantzic oak, seasoned,—uniform hollow cylindrical pillars of cast iron, whose sectional thickness is one inch,—also, uniform solid cylindrical pillars of cast iron and wrought iron.

| Length or height of Pillar in feet. | Number of diameters contained in length or height of Pillar. | Diameter or side of Square in inches. | Inter. diam. of Hollow Pillar in ins. | Solid Square Pillar of Red Deal (dry). Calculated break. weight in tons from formula, $W=7{\cdot}81\frac{D^4}{L^2}$. | Solid Square Pillar of Dantzic Oak (dry). Calculated break. weight in tons from formula, $W=10{\cdot}95\frac{D^4}{L^2}$. | Hollow Cylindrical Pillar of Cast Iron. Calculated breaking weight in tons from formula, $W=44{\cdot}34\frac{D^{3\cdot55}-d^{3\cdot55}}{L^{1\cdot7}}$ | Solid Cylindrical Pillar of Cast Iron. Calculated break. weight in tons from formula. $W=44{\cdot}16\frac{D^{3\cdot55}}{L^{1\cdot7}}$. | Solid Cylindrical Pillar of Wrought Iron. Calculated break. weight in tons from formula, $W=133{\cdot}75\frac{D^{3\cdot55}}{L^2}$. |
|---|---|---|---|---|---|---|---|---|
| 10½ | 31½ | 4 | 2 | 18·13 | 25·42 | 101 99 | 111·25 | 166·43 |
| 11 | 33 | 4 | 2 | 16·52 | 23·16 | 94·40 | 102·79 | 151·64 |
| 11½ | 34½ | 4 | 2 | 15·11 | 21·19 | 87·53 | 95·31 | 138·74 |
| 12 | 36 | 4 | 2 | 13 88 | 19·46 | 81·42 | 88·66 | 127·42 |
| 12½ | 37½ | 4 | 2 | 12·78 | 17·94 | 75·96 | 82·71 | 117·43 |
| 13 | 39 | 4 | 2 | 11·83 | 16·58 | 71·06 | 77·38 | 108·57 |
| 13½ | 40½ | 4 | 2 | 10·97 | 15·38 | 66·64 | 72·57 | 100·68 |
| 14 | 42 | 4 | 2 | 10·20 | 14·30 | 62·65 | 68·22 | 93·61 |
| 14½ | 43½ | 4 | 2 | 9 50 | 13·33 | 59 02 | 64 27 | 87·27 |
| 15 | 45 | 4 | 2 | 8·88 | 12·45 | 55·72 | 60·67 | 81·55 |
| 13 | 31 1-5 | 5 | 3 | 28 88 | 40·49 | 143·59 | 170·87 | 239·74 |
| 14 | 33 3-5 | 5 | 3 | 24·90 | 34·91 | 126·59 | 150·64 | 206·71 |
| 15 | 36 | 5 | 3 | 21·69 | 30 41 | 112·58 | 133·97 | 180 07 |
| 16 | 38 2-5 | 5 | 3 | 19·06 | 27·51 | 100·88 | 120·05 | 158·26 |
| 17 | 40 4-5 | 5 | 3 | 16·89 | 23·68 | 91·00 | 108·29 | 140·19 |
| 18 | 43 1-5 | 5 | 3 | 15·06 | 21 12 | 82 57 | 98 26 | 125·05 |
| 19 | 45 3-5 | 5 | 3 | 13 52 | 18 95 | 75·32 | 89·63 | 112·23 |
| 20 | 48 | 5 | 3 | 12·20 | 17·10 | 69 03 | 82·15 | 101·29 |
| 16 | 32 | 6 | 4 | 39·53 | 55 43 | 175 67 | 229·32 | 302 33 |
| 17 | 34 | 6 | 4 | 35 02 | 49·10 | 158·46 | 206·86 | 267·81 |
| 17½ | 35 | 6 | 4 | 33 05 | 46·34 | 150·85 | 196·92 | 252·76 |
| 18 | 36 | 6 | 4 | 31·24 | 43 80 | 143·79 | 187·71 | 238·88 |
| 19 | 38 | 6 | 4 | 28·03 | 39 31 | 131·16 | 171·22 | 214·39 |
| 20 | 40 | 6 | 4 | 25 31 | 35·48 | 120·21 | 156·93 | 193·52 |
| 18 | 30 6-7 | 7 | 5 | 57·87 | 81 14 | 227·11 | 324 46 | 412·89 |
| 19 | 32 4-7 | 7 | 5 | 51·94 | 72·82 | 207·16 | 295 96 | 370·58 |
| 20 | 34 2-7 | 7 | 5 | 46·87 | 65·72 | 189 86 | 271 24 | 334·44 |
| 22 | 33 | 8 | 6 | 66·09 | 92·66 | 238·08 | 370·57 | 444·03 |
| 24 | 36 | 8 | 6 | 55 53 | 77·86 | 205·35 | 319·62 | 373·11 |
| 26 | 39 | 8 | 6 | 47·32 | 66 34 | 179·22 | 278·96 | 317·91 |
| 28 | 42 | 8 | 6 | 40·80 | 57·20 | 158 01 | 245·94 | 274·12 |
| 30 | 45 | 8 | 6 | 35·54 | 49·83 | 140 52 | 218 72 | 238·79 |
| 35 | 52½ | 8 | 6 | 26·11 | 36·61 | 108·12 | 168·30 | 175 43 |
| 40 | 60 | 8 | 6 | 19·99 | 28 03 | 86·14 | 134·11 | 134·32 |

Tables showing the calculated breaking weight and safe weight of uniform hollow cylindrical pillars of cast iron, and the calculated weight of metal contained in each pillar.

Formula for long flexible pillars of cast iron, their length or height exceeding 30 times their external diameters, both ends of the pillars being flat and firmly fixed:—

$$W = 44{\cdot}34 \frac{D^{3.55} - d^{3.55}}{L^{1.7}}.$$

Formula for shorter pillars:—

$$Y = \frac{b\,c}{b + \frac{3}{4}c}.$$

NOTE.—The value of Y in the above formula is compounded of two quantities: $b$, the strength as obtained from the above formula for long flexible pillars; and $c$, the crushing force of the material.

*Hollow Uniform Cylindrical Pillars of Cast Iron, Both Ends being Flat and Firmly Fixed.*

| Length or height of Pillar in feet. | Number of diameters contained in the length or height. | External diameter in inches. | Internal diameter in inches. | Calculated weight of metal contained in the pillar in lbs. | Calculated breaking weight in tons from formula, $W = 44{\cdot}34 \frac{D^{3\cdot55} - d^{3\cdot55}}{L^{1\cdot7}}$. | Safe weight in tons. |
|---|---|---|---|---|---|---|
| 8 | 32 | 3 | $1\frac{1}{2}$ | 132·32 | 58·41 | 14·60 |
| 9 | 36 | " | " | 148·86 | 47.81 | 11·95 |
| 10 | 40 | " | " | 165·40 | 39·97 | 9·99 |
| 11 | 44 | " | " | 181·94 | 33·99 | 8·49 |
| 12 | 48 | " | " | 198 48 | 29·31 | 7·32 |
| 13 | 52 | " | " | 215·02 | 25 58 | 6·39 |
| 14 | 56 | " | " | 231·56 | 22·56 | 5·64 |
| 15 | 60 | " | " | 248·10 | 20·06 | 5·01 |
| 16 | 64 | " | " | 264·64 | 17·97 | 4·49 |
| 17 | 68 | " | " | 281·18 | 16·21 | 4·05 |
| 18 | 72 | " | " | 297 72 | 14·71 | 3·67 |
| 19 | 76 | " | " | 314·26 | 13·42 | 3 35 |
| 20 | 80 | " | " | 330·81 | 12 30 | 3·07 |
| 21 | 84 | " | " | 347·35 | 11·32 | 2·83 |
| 22 | 88 | " | " | 363 89 | 10 46 | 2·61 |
| 23 | 92 | " | " | 380 43 | 9·70 | 2·42 |
| 24 | 96 | " | " | 396·97 | 9·02 | 2·25 |
| 25 | 100 | " | " | 413·51 | 8·41 | 2·10 |
| 26 | 104 | " | " | 430·05 | 7 87 | 1·96 |
| 27 | 108 | " | " | 446 59 | 7·38 | 1·84 |
| 28 | 112 | " | " | 463·13 | 6·94 | 1·73 |
| 29 | 116 | " | " | 479·67 | 6·54 | 1·63 |
| 30 | 120 | " | " | 496·21 | 6·17 | 1·54 |

*Hollow Uniform Cylindrical Pillars of Cast Iron, Both Ends being Flat and Firmly Fixed.*

| Length or height of Pillar in feet. | Number of diameters contained in the length or height. | External diameter in inches. | Internal diameter in inches. | Calculated weight of metal contained in the Pillar in lbs. | Calculated breaking weight in tons from formula. $W = 44\cdot34 \frac{D^{3\cdot55} - d^{3\cdot55}}{L^{1\cdot7}}$. | Calculated breaking weight in tons from formula, $Y = \frac{bc}{b + \frac{3}{4}c}$. | Safe weight in tons. |
|---|---|---|---|---|---|---|---|
| 8 | 24 | 4 | $2\frac{1}{2}$ | 191·13 | | 126·95 | 31·73 |
| 9 | 27 | " | " | 215·02 | | 110 72 | 27·68 |
| 10 | 30 | " | " | 238 91 | | 97·26 | 24·31 |
| 11 | 33 | " | " | 262·81 | 83·75 | | 20·93 |
| 12 | 36 | " | " | 286·70 | 72·23 | | 18·05 |
| 13 | 39 | " | " | 310·59 | 63 04 | | 15·76 |
| 14 | 42 | " | " | 334·48 | 55 58 | | 13 89 |
| 15 | 45 | " | " | 358·37 | 49 43 | | 12·35 |
| 16 | 48 | " | " | 382 26 | 44·29 | | 11·07 |
| 17 | 51 | " | " | 406·16 | 39 95 | | 9 98 |
| 18 | 54 | " | " | 430·05 | 36·25 | | 9 06 |
| 19 | 57 | " | " | 453·94 | 33·07 | | 8·26 |
| 20 | 60 | " | " | 477·83 | 30·31 | | 7 57 |
| 21 | 63 | " | " | 501·72 | 27 89 | | 6·97 |
| 22 | 66 | " | " | 525 62 | 25·77 | | 6·44 |
| 23 | 69 | " | " | 549·51 | 23·90 | | 5·97 |
| 24 | 72 | " | " | 573·40 | 22·23 | | 5·55 |
| 25 | 75 | " | " | 597·29 | 20 74 | | 5·18 |
| 26 | 78 | " | " | 621·18 | 19·10 | | 4·85 |
| 27 | 81 | " | " | 645·08 | 18·19 | | 4·54 |
| 28 | 84 | " | " | 668·97 | 17·10 | | 4·27 |
| 29 | 87 | " | " | 692·86 | 16·11 | | 4·02 |
| 30 | 90 | " | " | 716·75 | 15·21 | | 3 80 |

*Hollow Uniform Cylindrical Pillars of Cast Iron, Both Ends being Flat and Firmly Fixed.*

| Length or height of Pillar in feet. | Number of diameters contained in the length or height. | External diameter in inches. | Internal diameter in inches. | Calculated weight of metal contained in the Pillar in lbs. | Calculated breaking weight in tons from formula, $W = 44\cdot34 \frac{D^{3\cdot55} - d^{3\cdot55}}{L^{1\cdot7}}$. | Calculated breaking weight in tons from formula, $Y = \frac{bc}{b + \frac{3}{4}c}$. | Safe weight in tons. |
|---|---|---|---|---|---|---|---|
| 8 | 19 1-5 | 5 | $3\frac{1}{2}$ | 249 94 | | 212·52 | 53·13 |
| 9 | 21 3-5 | " | " | 281·18 | | 188·80 | 47 20 |
| 10 | 24 | " | " | 312 43 | | 168·47 | 42·14 |
| 11 | 26 2-5 | " | " | 343·67 | | 151·03 | 37·75 |
| 12 | 28 4-5 | " | " | 374 91 | | 136 02 | 34 00 |
| 13 | 31 1-5 | " | " | 406 16 | 123·20 | | 30·80 |
| 14 | 33 3-5 | " | " | 437·40 | 108·61 | | 27·15 |
| 15 | 36 | " | " | 468·64 | 96·59 | | 24·14 |
| 16 | 38 2-5 | " | " | 499 89 | 86·55 | | 21·63 |
| 17 | 40 4-5 | " | " | 531·13 | 78 08 | | 19·52 |
| 18 | 43 1-5 | " | " | 562·37 | 70·85 | | 17·71 |
| 19 | 45 3-5 | " | " | 593·62 | 64·62 | | 16·15 |
| 20 | 48 | " | " | 624·86 | 59·23 | | 14·80 |
| 21 | 50 2-5 | " | " | 656·10 | 54·51 | | 13·62 |
| 22 | 52 4-5 | " | " | 687·35 | 50·37 | | 12·59 |
| 23 | 55 1-5 | " | " | 718 59 | 46·70 | | 11·67 |
| 24 | 57 3-5 | " | " | 749·83 | 43·40 | | 10·85 |
| 25 | 60 | " | " | 781·08 | 40·53 | | 10·13 |
| 26 | 62 2-5 | " | " | 812·32 | 37 91 | | 9·47 |
| 27 | 64 4-5 | " | " | 843·56 | 35·56 | | 8 89 |
| 28 | 67 1-5 | " | " | 874 80 | 33·43 | | 8·35 |
| 29 | 69 3-5 | " | " | 906·05 | 31·49 | | 7·87 |
| 30 | 72 | " | " | 937·29 | 29·73 | | 7·43 |

*Hollow Uniform Cylindrical Pillars of Cast Iron, Both Ends being Flat and Firmly Fixed.*

| Length or height of Pillar in feet. | Number of diameters contained in the length or height. | External diameter in inches. | Internal diameter in inches. | Calculated weight of metal contained in the Pillar in lbs. | Calculated breaking weight in tons from formula, $W = 44{\cdot}34\,\frac{D^{3{\cdot}55} - d^{3{\cdot}55}}{L^{1{\cdot}7}}$. | Calculated breaking weight in tons from formula, $Y = \frac{b\,c}{b + \frac{3}{4}c}$. | Safe weight in tons. |
|---|---|---|---|---|---|---|---|
| 8 | 16 | 6 | $4\frac{1}{2}$ | 308·76 | | 310·91 | 77·72 |
| 9 | 18 | " | " | 347·36 | | 280·61 | 70·15 |
| 10 | 20 | " | " | 385·96 | | 253·86 | 63·46 |
| 11 | 22 | " | " | 424·55 | | 230·32 | 57·58 |
| 12 | 24 | " | " | 463·15 | | 209·59 | 52·39 |
| 13 | 26 | " | " | 501·71 | | 191·35 | 47·83 |
| 14 | 28 | " | " | 540·34 | | 175·20 | 43·80 |
| 15 | 30 | " | " | 578·94 | | 161·00 | 40·25 |
| 16 | 32 | " | " | 617·53 | 147·33 | | 36·83 |
| 17 | 34 | " | " | 656·13 | 132·90 | | 33·22 |
| 18 | 36 | " | " | 694·73 | 120·60 | | 30·15 |
| 19 | 38 | " | " | 733·32 | 110·01 | | 27·50 |
| 20 | 40 | " | " | 771·92 | 100·82 | | 25·20 |
| 21 | 42 | " | " | 810·51 | 92·79 | | 23·19 |
| 22 | 44 | " | " | 849·11 | 85·74 | | 21·43 |
| 23 | 46 | " | " | 887·71 | 79·50 | | 19·87 |
| 24 | 48 | " | " | 926·30 | 73·95 | | 18·48 |
| 25 | 50 | " | " | 964·90 | 68·99 | | 17·24 |
| 26 | 52 | " | " | 1003·49 | 64·54 | | 16·13 |
| 27 | 54 | " | " | 1042·09 | 60·53 | | 15·13 |
| 28 | 56 | " | " | 1080·69 | 56·90 | | 14·22 |
| 29 | 58 | " | " | 1119·28 | 53·61 | | 13·40 |
| 30 | 60 | " | " | 1157·88 | 50·60 | | 12·65 |

*Hollow Uniform Cylindrical Pillars of Cast Iron, Both Ends being Flat and Firmly Fixed.*

| Length or height of Pillar in feet. | Number of diameters contained in the length or height. | External diameter in inches. | Internal diameter in inches. | Calculated weight of metal contained in the Pillar in lbs. | Calculated breaking weight in tons from formula, $W = 44{\cdot}34\,\frac{D^{3{\cdot}55} - d^{3{\cdot}55}}{L^{1{\cdot}7}}$. | Calculated breaking weight in tons from formula, $Y = \frac{b\,c}{b + \frac{3}{4}c}$. | Safe weight in tons. |
|---|---|---|---|---|---|---|---|
| 8 | 13 5-7 | 7 | $5\frac{1}{2}$ | 367·56 | | 417·76 | 104·44 |
| 9 | 15 3-7 | " | " | 413·51 | | 382·08 | 95·52 |
| 10 | 17 1-7 | " | " | 459·15 | | 349·79 | 87·44 |
| 11 | 18 6-7 | " | " | 505·10 | | 320·71 | 80·17 |
| 12 | 20 4-7 | " | " | 551·35 | | 294·61 | 73·65 |
| 13 | 22 2-7 | " | " | 597·29 | | 271·20 | 67·80 |
| 14 | 24 | " | " | 643·21 | | 250·23 | 62·55 |
| 15 | 25 5-7 | " | " | 689·18 | | 231·42 | 57·85 |
| 16 | 27 3-7 | " | " | 735·13 | | 214·52 | 53·63 |
| 17 | 29 1-7 | " | " | 781·08 | | 199·31 | 49·82 |
| 18 | 30 6-7 | " | " | 827·02 | | 185·61 | 46·40 |
| 19 | 32 4-7 | " | " | 872·97 | 170·93 | | 42·73 |
| 20 | 34 2-7 | " | " | 918·91 | 156·65 | | 39·16 |
| 21 | 36 | " | " | 964·86 | 144·18 | | 36·04 |
| 22 | 37 6-7 | " | " | 1010·80 | 133·22 | | 33·30 |
| 23 | 39 3-7 | " | " | 1056·75 | 123·52 | | 30·88 |
| 24 | 41 1-7 | " | " | 1102·70 | 114·90 | | 28·72 |
| 25 | 42 6-7 | " | " | 1148·61 | 107·20 | | 26·80 |
| 26 | 44 4-7 | " | " | 1194·59 | 100·28 | | 25·07 |
| 27 | 46 2-7 | " | " | 1240·53 | 94·05 | | 23·51 |
| 28 | 48 | " | " | 1286·48 | 88·41 | | 22·10 |
| 29 | 49 5-7 | " | " | 1332·43 | 83·29 | | 20·82 |
| 30 | 51 3-7 | " | " | 1378·37 | 78·63 | | 19·65 |

## *Experiments with the Disc Wheel in Propelling Steamboats.*

From the Journal of the Society of Arts, No. 421.

On Tuesday, the 11th inst., an experiment of a novel mode of propulsion in steam navigation was made in a trip from Blackwall to Erith. The paddle wheel and screw have hitherto been the means employed for utilizing steam power in navigation, but Mr. James Jones Aston, of the Middle Temple, has, it appears, taken out a patent for propelling steamships by a very different contrivance. *A priori*, the arrangement invented by Mr. Aston is the very last that would suggest itself to an observer, and the inventor himself candidly admits that both practical men and men of science ridiculed his idea when first propounded. The steam tug *Saucy Jack*—by no means a favorable boat for the success of the experiment—was propelled down the river at a rate of six knots an hour by the agency of a disc wheel, and with a far less expenditure of coal than if either paddles or screw had been used. The earliest objection to the locomotive was that it would not "bite" the rail, but the experiment soon proved the objection to be worthless. It is still more difficult to conceive what hold a thin metal or wooden plate, not striking the water horizontally or obliquely, but cutting into it edgewise, like a knife, can have of the water. The diameter of the disc used in the experiment was 14 feet, with about two feet in the water. The thickness of the plate was only three-eighths of an inch, and it is asserted that the thinner the plate the greater the power. The engines of the tug were 30-inch with a stroke of 42. The greatest number of revolutions made was 47. In the trip down the river the pressure in the boilers was 6 lbs., and coming up 4 lbs., the speed attained being about six knots. With the paddles the tug used to make about eight knots, but the expenditure of fuel was about 40 per cent. in favor of the disc. The conditions under which the trial was made were unfavorable to the experiment. She was not so readily started or so speedily stopped as the ordinary steamboats, but, perhaps, these disadvantages may disappear under more favorable circumstances. The disc may be constructed of metal or wood, or of both in combination, and several discs may be used on the same shaft, at convenient distances apart. There were five plates on each side in this experiment. The advantages of the disc, as enumerated by the inventor, are the following:

1. It is less likely to be disabled in a storm or battle, and is therefore a safer propeller.

2. There are no paddles or blades to agitate the water, and the boat is free from vibration.

3. All the action of the propeller is in the direction in which the boat travels, and the motive power being more perfectly utilized, a much greater rate of speed may be attained than has hitherto been deemed practicable.

4. Its action is perpetual and not intermittent.

5. There is no backwater, or loss of power on that account.

6. It is much less affected by wind and tide.

7. It is the only propeller well suited for canals and shallow rivers.
8. It may be used for small boats and other craft.
9. It may be worked with lower power and at great saving of fuel.
10. It is of more simple construction, less costly, less liable to injury, and causes less wear and tear of the boat.

There were present to witness the experiment:—Capt. Lovell, of the Peninsular and Oriental Company, Mr. Wright, Assistant-engineer-in-chief to the Admiralty, Mr. Adams, Mr. Macrory, and Mr. Aston himself, the inventor and patentee.

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## *On the Strength of Boilers.* By J. McF. Gray.

From the Lond. Artizan, Feb., 1861.

Fairbairn's experiments on the strength of boiler plates, of internal flues, of flat surfaces, and of riveted joints, have afforded the engineer precise data on which to base his rules for boiler construction. These experiments are described in "Useful Information for Engineers." In making notes from that work for my private use, I have chosen simple co-efficients for bursting strains, taken away the logarithmic character of the formula for collapsing of flues, and based a general law on the experiments on flat surfaces. The following rules, therefore, yield the same results as the various tables of the above work, and they have been framed so that they could be easily remembered, and the most of them calculated mentally. The law for the strength of flat surfaces is similar to that for the collapsing of tubes; and although it has not been pointed out as a law by Mr. Fairbairn, yet it is to his experiments we are indebted for its practical demonstration. As this law is here published for the first time and may surprise some, I will be more explicit with it than with the others, to show that it is theoretically correct, and that it is also in every respect confirmed by these experiments.

Taking the tensile strength of wrought iron plates at 23 tons per square inch, and the value of a riveted joint at 0·56 of the solid plate, or 28,750 pounds per square inch, Mr. Fairbairn ascribes a tensile strength of 34,000 pounds per square inch to the shell of a cylindrical boiler, as these boilers have the joints arranged to break band with each other. In the following rules for cylindrical shells I have adopted 34,000 as the standard of maximum strength. At the beginning of each rule the degree of approximation to this standard which is attained by using the co-efficients in the rule is indicated by a fractional quantity, in which the numerator is the ultimate strain per inch, and is as near as possible to 34,000. The denominator is the factor of safety for which the rule is constructed. Mr. Fairbairn gives *six* as the factor of safety for new boilers of good construction; this factor is to be taken as a limit to the pressure which a new boiler will bear with safety, and not as a rule for the regular working pressure of the boiler. To allow for deterioration, the bursting pressure of a boiler when new should be at least *eight* times the pressure at which it is intended that the boiler should be used. It is his opinion that "every

description of boiler used in manufactories or on board of steamers should be constructed to a bursting pressure of 400 to 500 lbs. on the square inch; and locomotive engine boilers which are subjected to a much severer duty, to a bursting pressure of 700 to 800 lbs.

At page 43 there is a table for thickness of the plates of a cylindrical boiler in decimal parts of an inch for a bursting pressure of 450 lbs. to the square inch, strain 34,000 lbs. per square inch: on examining the figures it appears to be calculated to a strain of 32,400—or, otherwise, that the pressure is not 450, but 472. The first of the following rules gives a result corresponding to that table.

### Cylindrical Shells—Internal Pressure.

(*Diameter in feet, thickness in inches, pressure in pounds per square inch.*)

1. $\left(\frac{32400}{1}\right)$ The thickness of the shell in inches for a bursting pressure of 450 lbs. per square inch is the diameter in feet divided by 12.

2. $\left(\frac{33600}{8}\right)$ The working pressure is 700 times the thickness divided by the diameter.

3. $\left(\frac{33600}{8}\right)$ The thickness of plates required for a cylindrical boiler is equal to the (product of the diameter by the working pressure) divided by 700.

4. $\left(\frac{33600}{8}\right)$ The greatest diameter of shell with a given thickness of plates and a given working pressure is 700 times the thickness divided by that pressure.

5. $\left(\frac{34000}{8}\right)$ For the working pressure of cylindrical boilers constructed of $\frac{3}{8}$ plates, divide the number 263 by the diameter of the boiler in feet.

6. $\left(\frac{34000}{8}\right)$ For the working pressure of cylindrical boilers constructed of $\frac{1}{2}$-inch plates, divide the number 354 by the diameter in feet.

### Collapsing of Internal Flues.

The experiments conducted by Mr. Fairbairn under the sanction of the Royal Society enabled him to establish a formula of strength for internal round flues. That formula is

$$P = 806{,}300 \frac{K^{2 \cdot 19}}{L\,D}.$$

Where P is the bursting pressure, K the thickness of the plate in inches, L the length of the flue, and D its diameter, both in feet.

This formula cannot be used but with the aid of logarithms, because of the index 2·19. Instead of this I have constructed the following rules:

7. The collapsing pressure of an internal cylindrical flue is 66 times the square of (one less than the number of thirty-seconds of an inch in the thickness of the plate), divided by the (product of the length by the diameter), both in feet.

8. The square root of the (product of the collapsing pressure, by the length, by the diameter, divided by 66) increased by 1, is the thickness of the plate in thirty-seconds of an inch.

The degree of approximation attained by this rule is, it is one-five-hundredth part of an inch below the thickness in the table for a flue 10 feet long, 1 foot diameter; and it is one-fiftieth of an inch above the thickness for a flue 30 feet long, 4 feet diameter, the collapsing pressure being 450 lbs. per square inch in both. The two rules agree when the plates are $\frac{1}{4}$ of an inch thick, also when the plates are $\frac{9}{16}$ of an inch thick; between these, this rule gives thinner plates, the greatest difference being when the plates are about $\frac{3}{8}$ of an inch thick; this rule gives the thickness $\frac{1}{300}$ of an inch less than is found by the logarithmic formula. For all other thicknesses this rule errs in excess of strength, and may thus be used for all plates from $\frac{3}{16}$ of an inch to $\frac{7}{8}$ of an inch thick.

### Strength of Flat Stayed Surfaces,

Such as the sides of the fire-box of a locomotive boiler, the stays being screwed into the plate without nuts.

From an examination of the sketch of the boxes experimented on by Mr. Fairbairn, showing the bulging of the plates, it appears that before the box burst, by one of the stays being drawn through the plate, the bulging of the plate was continued close up to that stay *without contrary flexure*, forming a conical surface around the stay. The plate gives way first at the insertion of the stay; at the inner edge of the hole the plate will be in a state of extension, and at the outer edge in a state of compression; and the *ultimate angular deflection* of the surface of the plate around the stay will be the same for equal thickness of plate whatever be the distance between the stays. The ultimate angular deflection at the stay being thus a constant, the ultimate linear deflection midway between the stays will be *simply as the distance of the stays.* If the conditions of the strains were such that the box would burst by the plate's rending at the middle of the bulgings, or midway between the stays, the ultimate pressure would be such that the total load on a square contained by four stays would be the same, whatever the distance of the stays might be. The ultimate linear deflection would then be as the square of the distance of the stays, as in beams of equal depth. In a beam the deflection is proportional to the load. If equal loads would produce deflections proportional to the *square of the distance*, loads which are *inversely as the distance of the stays* would produce deflections proportional to the *distance simply.* But the stay is drawn through the plate when the linear deflections are as the *distance simply*, therefore the ultimate load upon each square will be inversely as the distance between the stays.

The pressure per square inch is the total load per square between four stays, divided by the square of the distance between the stays; therefore the ultimate pressure per square inch will be inversely as the *cube of the distance between the stays*, for equal thickness of plates. For a different thickness of plates the pressure will be proportional to the square of the thickness of the plate.

It may appear from the tables of the progressive swelling of the sides of the boxes that the bulging did not follow this law. I apprehend that the bulging noted in the table with the first experiment is the swelling of the iron plate, not of the copper one. It was the copper plate that failed, and the sketch appears to agree with my reasoning on the subject.

Having now arrived at the form of the law, these experiments will afford us co-efficients, and will enable us to confirm the above principles.

As in the rule for the strength of internal flues I have taken the thickness in thirty-seconds of an inch, I will do the same here.

9. The bursting pressure of stayed flat iron plates is 720 times the (square of the thickness in thirty-seconds of an inch) divided by the (cube of the distance of the stays in inches).

10. The distance from centre to centre of the stays is equal to the cube root of $\left\{\right.$(720 times the square of the thickness in thirty-seconds of an inch) divided by the bursting pressure$\left.\right\}$.

11. The thickness of the plates in thirty-seconds of an inch is equal to the square root of $\left\{\right.$the product of the (cube of the distance of the stays) multiplied by the bursting pressure, divided by 720$\left.\right\}$.

12. For working pressures use 90 instead of 720. For copper plates use 400 for bursting pressure and 50 for working pressure.

These rules agree thoroughly with the experiments, and, as a corroboration of the principle, we can examine the ratio between the co-efficient for iron and that for copper. These co-efficients are to each other as 100 to 55½. The tensile strength of iron and copper stays were, by an experiment in the same appendix, found to be as 28,760 to 16,265, or as 100 to 56½. It may, however, be fairly objected that relative tensile strength is no criterion of these co-efficients. At page 129 of the above work the strength of wrought iron plates and of copper plates is given both for tension and compression, and the sum of the tension and compression in iron is to their sum in copper as 35 is to 19 or as 100 to 54½.

This rule does not apply when the plates are stiffened by angle irons or washer plates, but it shows the necessity of these when the stays are not as close as this rule would demand.

## Round Stays.

The tensile strength of wrought iron is taken at 23 tons, or 51,520 lbs. per square inch. The strain upon the section of each stay ought not to exceed one-eighth of this in fresh water boilers, that is, 6440 lbs. In boilers using salt water the factor of safety should be at least *ten*, or, the strain per square inch should not exceed 5152 lbs. In the following rules the co-efficient 5000 for fresh water gives a strain equal to 6361 lbs. per square inch. The co-efficient 4000, to be used for salt water, gives a strain equal to 5089 lbs. per square inch.

Note.—When the boiler is for salt water, use 4000 instead of 5000 in the following rules:

13. The working pressure per square inch is 5000 times the (square of the diameter of the stay) divided by the (square of the distance of the stays).

14. For every given pressure there is a constant ratio between the distance of the stays and their diameters. That ratio is the square root of (5000 divided by the working pressure per square inch).

15. If the ratio of distance to diameter be given, the pressure is found by dividing the number 5000 by the square of that ratio.

TABLE OF FORMULÆ FOR STRENGTH OF BOILERS.

| | |
|---|---|
| D = diameter in feet. | B = bursting pressure in lbs. per square inch. |
| L = length in feet. | C = collapsing do. do. |
| T = thickness in inches. | P = working do. do. |
| $t$ = thickness in thirty-seconds. | S = distance between stays in inches. |
| $d$ = diameter of stays in inches, at smallest part. | R = do. do. in diam. of stay. |

| | Strain per inch. | | | |
|---|---|---|---|---|
| Cylindrical boilers, | $\frac{32400}{1}$ | $B = 450$ | $T = \frac{D}{12}$ | $D = 12\,T$ |
| do. do. | $\frac{33600}{8}$ | $P = \frac{700\,T}{D}$ | $T = \frac{D\,P}{700}$ | $D = \frac{700\,T}{P}$ |
| do. do. | $\frac{34000}{8}$ | $P = \frac{263}{D}$ | $T = \frac{3}{8}$-inch. | $D = \frac{263}{P}$ |
| do. do. | $\frac{34000}{8}$ | $P = \frac{354}{D}$ | $T = \frac{1}{2}$-inch. | $D = \frac{354}{P}$ |
| Internal flues, from 3-16-in. to ⅞-in. plates, | $\frac{34000}{1}$ | $C = \frac{66\,(t-1)^2}{L\,D}$ | $t = 1 + \sqrt{\frac{C\,L\,D}{66}}$ | $D = \frac{66\,(t-1)^2}{C\,L}$ |
| Stayed flat surfaces, such as the sides of the fire-box of a locomotive boiler, the stays being screwed into the plates without nuts. — Iron | $\frac{31520}{1}$ | $B = \frac{720\,t^2}{S^3}$ | $t = \sqrt{\frac{B\,S^3}{720}}$ | $S = \sqrt[3]{\frac{720\,t^2}{B}}$ |
| Iron | $\frac{51520}{8}$ | $P = \frac{90\,t^2}{S^3}$ | $t = \sqrt{\frac{P\,S^3}{90}}$ | $S = \sqrt[3]{\frac{90\,t^2}{P}}$ |
| Copper | $\frac{28622}{1}$ | $B = \frac{400\,t^2}{S^3}$ | $t = \sqrt{\frac{B\,S^3}{400}}$ | $S = \sqrt[3]{\frac{400\,t^2}{B}}$ |
| Copper | $\frac{28622}{8}$ | $P = \frac{50\,t^2}{S^3}$ | $t = \sqrt{\frac{P\,S^3}{50}}$ | $S = \sqrt[3]{\frac{50\,t^2}{B}}$ |
| Round iron stays with fr. water, | $\frac{50928}{8}$ | $P = \frac{5000\,d^2}{S^2}$ | $d = S\sqrt{\frac{P}{5000}}$ | $S = d\sqrt{\frac{5000}{P}}$ |
| do. do. | $\frac{50928}{8}$ | $P = \frac{5000}{R^2}$ | $d = \frac{S}{R}$ | $R = \sqrt{\frac{5000}{P}}$ |
| do. with salt water, | $\frac{50928}{10}$ | $P = \frac{4000\,d^2}{S^2}$ | $d = S\sqrt{\frac{P}{4000}}$ | $S = d\sqrt{\frac{4000}{P}}$ |
| do. do. | $\frac{50928}{10}$ | $P = \frac{4000}{R^2}$ | $d = \frac{S}{R}$ | $R = \sqrt{\frac{4000}{P}}$ |

The following table gives these ratios, which are the distances between the stays expressed in diameters of the stay. Thus, at 50 lbs. pressure in a fresh water boiler, the distance between the centres of two stays is ten times the diameter of a stay.

| Ratio. | Pressure, fresh water, lbs. per sq. in. | Pressure, salt water, lbs. per sq. in. | Ratio. | Pressure, fresh water, lbs. per sq. in. | Pressure, salt water, lbs. per sq. in. |
|---|---|---|---|---|---|
| 4 | 312 | 250 | 11 | 41 | 33 |
| 5 | 200 | 160 | 12 | 35 | 30 |
| 6 | 139 | 111 | 13 | 30 | 24 |
| 7 | 102 | 81 | 14 | 25½ | 20 |
| 8 | 78 | 62 | 15 | 22 | 17 |
| 9 | 61 | 49 | 18 | 15 | 12½ |
| 10 | 50 | 40 | | | |

16. The diameter of the stay is equal to the distance between the stays divided by the square root of (5000 divided by the working pressure).

17. The distance between the stays is equal to the diameter of the stay multiplied by the square root of (5000 divided by the working pressure).

In the rule for flat surfaces I have assumed that the strength would vary as the square of the thickness of the plate. The experiments referred to do not enable us to test the truth of this, because the plates were of the same thickness in both experiments. In the collapsing of flues the strength increases in a higher ratio than that of the square of the thickness; but again, in experiments on the resistance of wrought iron plates to pressure by a blunt instrument at right angles to the surface it was found that the strengths were simply as the thickness. If this holds good in the case of flat surfaces submitted to steam pressure, the formulæ would be:

$$\text{B} = \frac{8666\,t}{\text{S}^3}, \text{ for iron plates.}$$

$$\text{B} = \frac{6370\,t}{\text{S}^3}, \text{ for copper plates.}$$

And here again we have co-efficients which are proportional to the tensile strength of iron and of copper, so that these data do not determine whether the strength is as the thickness, or as the square of the thickness of the plates. For $\frac{3}{8}$-inch iron plates or for $\frac{1}{2}$-inch copper plates, either rule will give the same result.

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## *Experiments on the Strength of Paddle Floats.*

From Mitchell's Steam-shipping Journal, No. 79.

The Royal paddle yacht *Victoria and Albert*, on the occasion of conveying the Empress of Austria to Madeira from Antwerp, sustained considerable injury to her paddle floats during the exceedingly violent weather she experienced throughout the trip, particularly on the outward voyage. Since she has been placed in dock at Portsmouth, where her floats have been unshipped and examined, it has become a question whether they could not be made from some more durable material than that which has been hitherto used—English oak. To ascertain this satisfactorily, a series of tests have been tried at Portsmouth during the past few days, and the result appears to be that it will be difficult to supersede English oak with any other material more durable for the purpose. Each float of the yacht's paddle measures 11 feet 6 inches in length by 4 feet 4 inches in width, the wood being 4 inches thick. One of these floats—a spare one—was tested. The others tested comprised two new ones of the same wood—English oak, one of American oak, and one of wrought iron, the latter being plates riveted together with a space between. The mode of testing was by

placing the float with its two ends resting on balks of timber. Across the centre of the float, transversely, ran a bar of iron 4 inches square, from which was suspended the weights for trying the float's resisting powers. The American oak broke at 32 tons. The wood forming this float was of the finest character, and most even grain, and without a knot in any part. One of the new English oak floats broke at 28 tons, and the other at 24 tons. These floats were much weakened by having iron plates on their surface, each containing 9 or 10 bolt holes. The one that broke at 28 tons, had it been without this iron plate and its accompanying bolt holes, would doubtless have stood as great a strain as the American oak. The *Victoria and Albert's* spare float broke at 21 tons, and the wrought iron one broke at 19 tons. Had the last mentioned one stood a favorable test, the galvanic action that must be constantly going on between a vessel's wheel floats composed of iron and the copper on her bottom would prove an insurmountable bar to its adoption.

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For the Journal of the Franklin Institute.

*Strength of Materials:* Deduced from the latest experiments of Barlow, Buchanan, Fairbairn, Hodgkinson, Stephenson, Major Wade, U. S. Ordnance Corps, and others. By Chas. H. Haswell, Civil and Marine Engineer.

No. 8.

(Continued from page 321.)

*Results of Experiments on the Transverse Strength and Deflection of Wrought Iron Rails* (Barlow).

| Rails. | | Weight per yard. | Length of bearing. | Depth. | Area. | Weight. | Deflection. For weight. | Deflection. For each ton. |
|---|---|---|---|---|---|---|---|---|
| | | lbs. | Feet. | Inch. | Inch. | lbs. | Inch. | Inch. |
|  | Flanches. 2·25 | 60 | 2·75 | 4·5 | 6·166 | 2240 | ·027 | — |
| | rib, ·65, | 60 | 2·75 | 4·5 | 6·166 | 4480 | ·031 | ·004 |
| | | 60 | 2·75 | 4·5 | 6·166 | 17920 | ·057 | ·005 |
| | " 2·6 × 1·25 ins. | 60 | 2·75 | 4·5 | 6·166 | 26680 | ·087 | ·010 |
| | rib, ·85, | 75 | 4·5 | 5· | 7·5 | 4480 | ·050 | — |
| | | 75 | 4·5 | 5· | 7·5 | 20160† | ·165 | ·023 |
|  | " 3·5 × ·6 in. | 57 | 2·75 | 3·5 | 5·85 | 4480 | ·050 | — |
| | rib, ·8, | 57 | 2·75 | 3·5 | 5·85 | 17920† | ·152 | ·039 |
|  | * Head, 2·25 × 1 in. rib, ·75 | 60 | 2·75 | 4· | 6·7 | 4480 | ·034‡ | — |
| | Flanch, 3·5 × ·8 | 60 | 2·75 | 4· | 6·7 | 17920 | ·064 | ·082 |
|  | Head, 2·5 × ·6 rib, ·6 Bottom, 1·25 × ·88 | 51 | 3· | 4·5 | 5·55 | 6720§ | ·024 | — |

* Equivalent dimensions. † Destructive weight.

‡ The deflection between this and a like bar to this, reversed, was, for between 5 and 10 tons weight, as ·0074 and ·0059.

§ Destructive weight 7 tons.

As it is impracticable to give any general rule for the deflection of

bars, beams, &c., of different lengths and sections, and when an experiment cannot be made to obtain the deflection in a particular case, reference must be had to the results of previous experiments upon bars, beams, &c., of a like character to that or those for which the deflection is required.

*Thus*, in the preceding tables, page 318 to 321, are given the deflections ascertained in very many cases, added to which is given a *value* or *constant* obtained by the formula

$$\frac{l^3\,\mathrm{W}}{16\,b\,d^3\,\mathrm{D}}.$$

*$l$ representing the length in feet,* D *the deflection, and $b$ and $d$ the breadth and depth in inches.*

In the first and second examples of the table are results of two experiments with a like material, but of differing dimensions.

In order, then, to determine the relative values of the constants, the varying elements of the case must be reduced to an uniform measure.

In the examples referred to, the *Values* or constants are as 187 and 292, their sections ($b\,d^3$) as 12 and 16, the weights applied as 120 and 420, and the lengths as $3^3$ and $4^3$.

If the deflections were in conformance with the formula, the *Values* here deduced would be equal, instead of 187 and 292, the proportion of which is obtained by $\frac{187}{292} = \cdot 64$ of the deflection given by the formula. The deflection as furnished by the table for the second experiment is $\cdot 36$; *hence*, as $\cdot 64 : 1 :: \cdot 36 : \cdot 56 =$ the calculated deflection of it.

*When it is required to estimate the deflection for differing weights, lengths, and sections, and contrariwise, to estimate the weights, lengths, and sections for a given deflection.*

Divide the deflections by the cubes of the lengths and by the weights. Or, multiply the deflections by the sections ($b\,d^3$). Thus, if the deflections are as $\cdot 15$ and $1\cdot 20$ inches, the weights as 125 and 250 lbs., the lengths as 1 and 2 feet, and the sections as $1 \times 2^3$ and $2 \times 2^3$ inches.

$\frac{\cdot 15}{1\cdot 20} \div \frac{1^3}{2^3} = \frac{\cdot 15}{\cdot 15} =$ *quotient of the deflections ÷ the cubes of the lengths, which, being equal, shows the deflections to be as the cubes of the lengths.*

$\frac{\cdot 15}{\cdot 15} \div \frac{125}{250} = \frac{\cdot 0012}{\cdot 0006} = \frac{2}{1} =$ *quotient of the reduced deflection ÷ the weights; hence, the deflections are but one-half of that due to the weights.*

$\frac{2}{1} \times \frac{1 \times 2^3}{2 \times 2^3} = \frac{16}{16} = \frac{1}{1} =$ *product of the preceding quotient and the sections ($b\,d^3$); hence, the reduced deflections to be as the sections.*

*Table of the Relative Elasticity of Various Materials* (Trumbull).

| | | | |
|---|---|---|---|
| Cast iron, | 1· | Oak, | 2·8 |
| Wrought iron, | ·86 | Pine, white | 2·4 |
| Ash, | 2·6 | " yellow, | 2·6 |
| Beech, | 2·1 | " pitch, | 2·9 |
| Elm, | 2·9 | | |

## General Deductions.

In cast iron the permanent deflection is from one-third to one-fourth of its breaking weight, and the deflection should never exceed one-third of the ultimate deflection.

All rectangular bars of wrought iron, having the same bearing length and loaded in their centre to the full extent of their elastic power, will be so deflected that their deflection being multiplied by their depth, the product will be a constant quantity, whatever may be their breadth or other dimensions, provided their lengths are the same.

The heaviest running weight that a bridge is subjected to is that of a locomotive and tender, which is equal to 1·5 tons per lineal foot.

Girders should not be deflected to exceed the 40th of an inch to a foot in length.

In cast iron the $\frac{1}{20}$th to $\frac{1}{30}$th of the breaking weight will give a visible set.

When a load on a girder is supported by the bottom flanch of it alone it produces a torsional strain.

A continuous weight, equal to that a beam, &c., is suited to sustain, will not cause the deflection of it to increase, unless it is subjected to considerable changes of temperature.

The heaviest load on a railway girder should not exceed $\frac{1}{6}$th of that of the breaking weight of the girder when laid on at rest.

*Deflection Consequent upon Velocity of the Load.*—Deflection is very much increased by instantaneous loading; by some authorities it is estimated to be doubled.

The momentum of a railway train in deflecting girders, &c., is greater than the effect from the dead weight of it, and the deflection increases with the velocity.

Experiments made by the Commissioners of Railway Structures of 1849, showed that a passing load produced a greater effect on a beam than a load at rest.

A carriage was moved at a velocity of 10 miles per hour; the deflection was ·8 inch, and when at a velocity of 30 miles the deflection was 1·5 inches.

In this case 4150 lbs. would have been the breaking weight of the bars, if applied in their middle, but 1778 lbs. would have broken them if passed over them with a velocity of 30 miles per hour.

Cast iron will bend to one-third of its ultimate deflection with less than one-third of its breaking weight if it is laid on gradually, and but one-sixth if laid on rapidly.

When motion is given to the load on a beam, &c., the point of greatest deflection does not remain in the centre of the beam, &c., as beams

broken by a traveling load are always fractured at points beyond their centres and often into several pieces.

Chilled bars of cast iron deflect more readily than unchilled.

*Mean Results of Experiments on the Deflection of a pair of Bars by the Transit of a Load at Different Velocities.* (Rep. Comms. on Railway Structures.)

CAST IRON.

LENGTH BETWEEN THE SUPPORTS 9 FEET.

| VELOCITY. | Depth. | Breadth. | Weight of load. | Deflection. | Set. | Breaking weight. |
|---|---|---|---|---|---|---|
| | Inch. | Inch. | lbs. | Inch. | Inch. | lbs. |
| At rest, . . | 2· | 1 | 1120 | ·87 | ·24 | |
| | | | 2242 | 4·41 | 1·43 | 2256 |
| | 3· | 1 | 1120 | ·35 | ·08 | 4235 |
| 15 feet per second, | 2· | 1 | 1120 | 1·39 | ·21 | 1842 |
| . | 3· | 1 | 1120 | ·38 | ·07 | 3400 |
| 24 " " | 2· | 1 | 1120 | 1·48 | ·15 | 1520 |
| | | | 1496 | 3·94 | 1 07 | 1524 |
| 29 " " | 2· | 1 | 1120 | 2·28 | ·20 | 1216 |
| 33 " " | 2· | 1 | 1120 | 2·32 | ·36 | 1213 |
| 36 " " | 2· | 1 | 1120 | 2·31 | ·21 | 1176 |
| 43 " " | 3· | 1 | 1120 | ·45 | ·05 | 2182 |
| LENGTH BETWEEN THE SUPPORTS 13 FEET 6 INCHES. | | | | | | |
| At rest, . . | 3· | 1 | 1120 | 1·35 | ·20 | 3124 |
| 43 feet per second, | 3· | 1 | 1120 | 2 68 | ·26 | 1516 |
| WROUGHT IRON. | | | | | | |
| LENGTH BETWEEN THE SUPPORTS 9 FEET. | | | | | | |
| At rest, . . | 3· | 1 | 1120 | ·15 | — | — |
| | 3· | 1 | 1778 | ·31 | — | — |
| 15 feet per second, | 3· | 1 | 1778 | ·38 | — | — |
| 29 " " | 3· | 1 | 1778 | ·50 | — | — |
| 36 " " | 3· | 1 | 1778 | ·62 | — | — |
| 43 " " | 3· | 1 | 1778 | ·46 | — | — |
| STEEL. | | | | | | |
| LENGTH BETWEEN THE SUPPORTS 2 FEET 3 INCHES. | | | | | | |
| At rest, . . | ·25 | 2 | 1120 | ·70 | — | — |
| 15 feet per second, | ·25 | 2 | 1120 | 1·02 | — | — |
| 29 " " | ·25 | 2 | 1120 | 1·46 | — | — |

*Mean Results of Experiments to Ascertain the Deflections of Bars, Beams, &c., when the Load is suddenly applied, but without Impact.* (Rep. Comms. on Railway Structures.)

CAST IRON.

LENGTH BETWEEN THE SUPPORTS 9 FEET.

| Depth. | Breadth. | Weight. | Deflection and set. Load applied. Gently. | | Suddenly. | | Breaking weight. |
|---|---|---|---|---|---|---|---|
| Inch. | Inch. | lbs. | Inch. | Inch. | Inch. | Inch. | lbs. |
| 2· | 1 | 448 | 1·24 | ·19 | 2·05 | ·43 | 602 |
| 3· | 1 | 784 | ·59 | ·06 | 1·08 | ·13 | 1231 |
| 1·5 | 4 | 784 | 1·28 | ·10 | 2·26 | ·24 | 1053 |

*Results of Experiments on the Subjection of Iron Bars to Continual Strains* (Rep. Comms. on Railway Structures).

Cast iron bars subjected to a regular depression, equal to the deflection due to a load of one-third of their statical breaking weight, bore 10,000 successive depressions, and when broken by statical weight gave

as great a resistance as like bars subjected to a like deflection by statical weight.

Of two bars subjected to a deflection equal to that carried by half of their statical breaking weight, one broke with 28,602 depressions, and the other bore 30,000 and did not appear weakened to resist statical pressure.

Of a number of bars subjected to a vibratory depression, equal to the deflection due to a load of one-third of their statical breaking weight, one broke at 51,538 depressions, and one bore 100,000 without any apparent diminution of resistance.

Of three bars subjected to a like character of depression, equal to the deflection due to a load of one-half of their statical breaking weight, they broke at 490,617, and 900 depressions respectively.

*Hence*, cast iron bars will not bear the continual applications of one-third of their breaking weight.

A bar of wrought iron, 2 inches square and 9 feet in length between its supports, was subjected to 100,000 vibratory depressions, each equal to the deflection due to a load of five-ninths of that which permanently injured a similar bar, and their depressions only produced a permanent set of ·015 inch.

Three wrought iron bars were subjected to 10,000 vibratory depressions, depressing them through one-third, two-thirds, and five-sixths of an inch respectively, without receiving any perceptible permanent set.

A bar of wrought iron depressed through one inch received a set of ·06 inch, and one depressed 300 times through two inches received a set of 1·08 inch.

The greatest deflection which did not produce any permanent set was due to rather more than one-half the statical weight, which permanently injured it.

A wrought iron box girder, 6 × 6 inches and 9 feet in length, was subjected to vibratory depressions, and a strain corresponding to 3752 lbs. repeated 43,370 times, did not produce any appreciable effect on the rivets.

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## *Room for Improvement in the Steam Engine.*

From the London Engineer, No. 252.

The unit of heat is that which is sufficient to raise the temperature of one pound of water by 1 deg. of Fah. The unit of work is the raising of one pound weight through a vertical height of one foot—called a foot pound. The experiments of Mr. Joule, of Manchester, indicated that if the whole of the heat could be rendered available, a unit of heat would raise 772 pounds 1 ft. high: in other words, a unit of heat is equal to 772 foot-pounds. This is called Joule's equivalent. A pound of charcoal will raise 78·15 pounds of water 180 deg., which is equal to 14,067 units of heat. This multiplied by 772, gives 10,859,724 foot-pounds, which is equal to the production of 5½ horse power from the combustion of 1 lb. of charcoal per hour. As the best engines consume nearly 2 lbs. of coal per horse power per hour, it follows that about only one-tenth part of the gross power of the fuel is utilized.

## *On the Resistance offered by Cast Iron to Internal Pressure.* By Mr. John Briggs.

From Newton's London Journal, March, 1861.

The author commenced by stating that he considered cast iron to be the most deceptive of all metals, for in addition to its liability to unsoundness in the process of casting, and fracture from unequal expansion, it was affected injuriously from a variety of other causes. Pig iron was iron in its most impure state, for it was contaminated by all the impurities which were capable of combining with it in its primitive form as ore, and which chemical affinity prevented its parting with in the process of smelting. Frequently, indeed, it was found that the same charge yielded iron of totally different qualities. It had occurred to the reader of the paper that some of the impurities which thus interfered with the character of cast iron were actually other metals, and modern chemistry supported the theory. Many mineral productions, which were formerly considered simple substances, had been proved to have metallic bases, from which had been obtained metals; for example—aluminium, barium, magnesium, calcium, and silicium. Then again manganese, which abounded in the Bowling and Low Moor irons, and which gave them their superiority for solidity and strength, and caused them to be largely used in the manufacture of heavy guns, might be mentioned. There were several other elements, such as carbon, sulpur and phosphorus, which more or less affected the character of cast iron. The first named gave fluidity and softness to the iron, while sulphur and phosphorus were the greatest enemies it had to contend against.

These were the primary points which those who employed cast iron in the construction of cylinders intended to resist great internal pressure—whether in the shape of pieces of ordnance or of hydraulic presses—had to deal with, and perhaps no one had labored more zealously to comprehend and explain them than had one of their own members—Mr. Keyte, when employed at Woolwich Arsenal The existence of the various substances and elements he (Mr. Briggs) had named, was doubtless due to the peculiarities of the localities in which the ore was obtained. In addition, however, he must be permitted to say, that the constitution of cast iron was materially affected by the manner of smelting it. It was necessary to exercise great care in this operation, and in making proper selections of different kinds of iron for particular purposes. The judgment of the iron founder must be largely relied on in this case; and it was well when that judgment was not at fault. Without detaining the meeting further, he should now reiterate the assertion, that cast iron was the most deceptive of all metals, and required to be dealt with accordingly. Mr. Briggs next referred more directly to the subject of his paper. There was a limit to the pressure which should be put internally to cast iron, and there was, he was bold to assert, a limit also to the *thickness* of metal to be used for cylinders of hydraulic presses. Such a statement might at the first blush, appear to be irrational. The general opinion would

undoubtedly be, that the thicker the iron, the greater its resistance to pressure where the bore remained the same size. This he believed not to be the case, and Mr. Joseph Bramah had long ago the same opinion. At the time that one of the press cylinders employed in raising the tubes of the Britannia-bridge had burst asunder, a workman, once in the employment of Messrs. Bramah, thus wrote to the *Mechanics' Magazine* (Sep. 29th, 1849): "At Bramah's we never found presses in constant work stand more than three tons (6720 lbs.) on the square inch, and the greatest pains were taken to obtain the most approved kinds of iron—mixed qualities—to cast cylinders from. I have seen press cylinders stand 7000 lbs. and even 8000 lbs. on the square inch under proof for a short time; but we never could trust them to work with so much, and cast iron then was far superior to that of the present day. Increasing the thickness of the metal in press cylinders was seldom successful. I have known metal 7 inches thick stand as well as that of $10\frac{1}{2}$ inches, for presses with rams 10 inches diameter. The thicker the metal, the greater appeared to be the difficulty in getting it equal and homogeneous throughout." The writer of the foregoing had assisted in the construction of upwards of 100 hydraulic presses at Bramah's, and his remarks came with all the weight, therefore, of authority based on experience. For himself he must say that his own experience, though more limited in extent, confirmed him in a like opinion. He, indeed, almost thought that the error at present consisted in making such cylinders too thick. If the metal were used thinner, there would be more certainty of obtaining castings of greater density and uniformity, and therefore, better calculated to sustain pressure. Mr. Briggs next adduced some instances of fractured cylinders, and referred to a list which he had, in a former paper, laid before the meeting. Experiment and experience, then, alike induced him to believe that there should be a limit to the thickness of all cylinders intended to resist high pressures.

Some examples touching the maximum of pressure to be employed were adverted to, and much information, of a practical nature, was given in relation to this part of the subject. The general conclusions arrived at by the author were as follows:—Three tons per circular inch he considered to be the bursting pressure of press cylinders. The maximum thickness of metal, when all due care had been exercised in its composition, should not be more than the radius of the bore of the cylinder. Two tons per circular inch was a safe pressure to work up to, and this he should pronounce to be his own standard. With these deductions, and with the announcement that at the next monthly meeting he would pursue the questions as to how the pressure is distributed, the commencement of fracture, the line of fracture, the direction of the forces within the cylinders, and introduce the opinions of the late Mr. Robert Stephenson, the author concluded his remarks.

During the discussion, which followed the reading of the paper, Mr. Ives (of Messrs. Grissel's) observed, that one important point in the manufacture of cylinders was the question as to whether the metal of which they were made should be hard or soft.

Mr. James Robertson (of Bankside) said the whole matter was one of great interest. The mysteries of cast iron were not yet revealed, and good iron sometimes became worthless from causes apparently inexplicable. Mechanical and chemical tests were frequently contradictory in relation to cast iron. He had a notion that despite the expense, wrought would be found the most fitting material for press cylinders. Still it was a debatable point.

Mr. Sanson agreed with Mr. Robertson as to the advisability of trying wrought iron. Many failures occurred in the casting of cylinders such as those under discussion, and the expense thus was much increased. Wrought iron guns had been proved far superior in all respects to cast; why not make hydraulic press cylinders of the same substance?

Mr. Davis agreed that cast cylinders might be made too thick, and in such case porosity was the enemy to be feared.

Mr. Keyte considered that it was an important assertion that thickness of metal did not increase strength, and one likely to lead to diversity of opinion indoors and out.

Mr. Aydon believed that cast steel was the best material after all for press cylinders. He should not hesitate to employ a pressure of ten tons to an inch in such a case.

Mr. Oubridge (of Messrs. Simpson's) said, the two main objects to be regarded were the proper mixture of the iron and the thickness of metal. With regard to the first, Mr. Ellis, one of their own members, and now with Watt and Company at Soho, had made many useful experiments, and he found that the quality of iron depended much on the fuel used in smelting it. That which was most free from sulphur was undoubtedly best.

Other members joined in the discussion, and after passing a vote of thanks to Mr. Briggs, the meeting reverted to another subject. This was a consideration of Mr. Ramsell's patent boiler plates, with undulating surfaces and plain edges. The nature of the invention was explained by Mr. Robertson with the aid of a model plate which he exhibited.—*Proceedings Association Foremen Engineers.*

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*Improvements in the Manufacture of Thin Sheet Lead Coated with Tin.—Specification of the Patent granted to* George Tosco Peppe. Dated March 22, 1860.

From the Repertory of Patent Inventions, Dec., 1860.

The thin sheets of lead herein referred to, are obtained by cutting from the outer surface of a mass or cylinder of lead, and I propose to utilize the fresh unoxidized surface of the thin sheet of lead so obtained, to deposit thereon a continuous, unbroken, and adherent coating of metallic tin, by means of the electro-plating process.

The electro-plating of lead has been attempted before, but has not been commercially successful, on account of the expense of cleaning the surface of other than thick sheets of lead, and the difficulty of obtaining by the electro-chemical process a proportionate thickness of

reguline or metallic tin to admit of profitable lamination with the lead by means of rollers.

The cleaning of thin sheets of lead by other than the cutting process, and upon which an adequate thickness of reguline tin can be deposited by electro-chemical means, so as to admit of lamination, being impracticable on account of the expense, I take advantage of the freshly cut unoxidized surface, which is incidentally obtained in the cutting process, to deposit on it a proportionate thickness of tin to bear lamination by rolling.

I take the thin sheet lead as it comes in a continuous sheet from the cutting machine and conduct it into a trough containing, by preference, stannate of soda, but other solutions may be used, such as the stannate of potash, or a solution of cyanide of potassium and tin. These solutions are maintained at a temperature varying from 150 degrees to 170 degrees of Fahrenheit, either by means of a gas stove underneath an earthenware trough, or by the injection of steam into a wooden trough. The depositing trough must not be made of any metal capable of having tin deposited upon it. The thin sheet lead is conducted along the bottom of the trough on a series of wooden rollers revolving freely on axes within the trough. The thickness of the coating of tin will depend upon the length of the depositing trough, and the speed with which it is passed along it, and also upon the intensity of the battery power employed, when the period during which the lead remains in the trough is limited. In the depositing trough, I suspend over the sheet lead a plate of metallic tin of the same dimensions as the immersed portion of the lead. This tin anode is connected with the positive pole of the battery or batteries employed, while the negative pole is connected with the sheet of lead either through the cutting machine or through the medium of the metallic rollers which receive the sheet lead as it emerges from the bath. The tin anode is kept from coming in contact with the sheet lead by means of wooden or glass supports, which can be elevated or depressed at pleasure, so as to regulate the distance between the lead and tin. I prefer to suspend the tin anode directly over the lead cathode, but it may be placed vertically when the lead is in the same position alongside it.

In cases where it is desired to plate the lead with a thicker coating of tin than can be deposited upon it during the time it is passing through the trough in connexion with the cutting machine, I first allow the lead to pass through the trough in order to prevent the surface from oxidation by the deposition of a thin coating of tin as before described. I cut the sheet lead as it comes from the machine into pieces of a convenient size, and immediately immerse them in thin solutions in suitable depositing troughs, having no connexion with the cutting machine, and having a tin anode, as before described, connected with the positive pole of the battery or batteries employed, while the lead is connected with the negative pole.

By increasing the intensity of the current of electricity while the quantity remains the same, the rapidity of deposition, and the thick-

ness of the tin coating, may be regulated with facility, and other means usually employed by electrotypists. When a sufficient thickness of the tin coating has been obtained, the lead is to be passed between laminating rollers until it is drawn out to the thinness required. By this means, the surface of the tin deposit is rendered bright and smooth. If required, the laminated lead may be again put into the depositing trough to receive a fresh coating of tin, and again extended and smoothed by passing between the rollers, and the same process may be repeated, so as to give any required degree of thickness to the tin coating. The lead so coated may be used as a material for wrapping up articles which are injuriously acted upon by lead, or it may be formed into capsules or covers for closing the mouths of bottles and other vessels.

Having described the nature of my invention and how it is to be performed, I do not claim the cutting of thin sheets of lead from a revolving cylinder, nor do I claim the deposition of tin on surfaces of lead prepared by other than the cutting process; what I do claim is, the utilization of the fresh and clean surface incidentally produced by the cutting process, to apply thereto a continuous, unbroken, and adherent coating of metallic tin, of sufficient thickness in proportion to the lead to admit of lamination, or rolling into thin leaves, without exposing the lead surface.

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## *New Zealand Steel.*

From the Lond. Mechanics' Magazine, Dec., 1860.

Ever since the settlement of New Zealand by Europeans, their attention has been daily called to the peculiarities of a kind of metallic sand along the shores of New Plymouth, in Taranaki. This sand has the appearance of fine steel filings, and if a magnet be dropped upon it, and taken up again, the instrument will be found thickly coated with the iron granules. Our attention was recently drawn to this singular substance by a friend, and the *Australian Mail* now gives a lengthy account of it. It states that the place where the sand abounds is along the base of Mount Egmont, an extinct volcano, and the deposit extends several miles along the coast, to the depth of many feet, and having a corresponding breadth. The geological supposition is, that this granulated metal has been thrown out of the volcano, along the base of which it rests, into the sea, and there pulverized. The quantity is so large, that people out there looked upon it as utterly valueless. Captain Morshead, a gentleman in the West of England, was so much impressed with its value, that he went to New Zealand to verify the reports made to him in this country, and was fortunate enough to find them all correct. He smelted the ore first in a crucible, and subsequently in a furnace; the results were so satisfactory, that he immediately obtained the necessary grant of the sand from the government, and returned to England with several tons for more conclusive experiments. It has been carefully analyzed in this country by several well-known metallurgists, and has been pronounced to be

the purest ore at present known; it contains 88·45 of peroxide of iron, 11·43 of oxide of titanium, with silica, and only ·12 of waste in 100 parts. Taking the sand as it lies on the beach and smelting it, the produce is 61 per cent. of iron of the very finest quality; and, again, if this sand be subjected to the cementation process, the result is a tough, first-class steel, which, in its properties, seems to surpass any other description of that metal at present known. The investigations of metallurgical science have found that, if titanium is mixed with iron, the character of the steel is materially improved; but, titanium being a scarce ore, such a mixture is too expensive for ordinary purposes. Here, however, nature has stepped in, and made free gift of both metals on the largest scale. To give some idea of the fineness of this beautiful sand, it will be enough to say that it passes readily through a gauze sieve of 4900 holes or interstices to the square inch. As soon as it was turned into steel, by Mr. Mushet of Coleford, Messrs. Moseley, the eminent cutlers and toolmakers, of New street, Covent Garden, were requested to see what could be done with the Taranaki steel. They have tested it in every possible way, and have tried its temper to the utmost, and they say the manner in which the metal has passed through their trials, goes far beyond any thing that they ever worked in steel before. Messrs. Moseley, in whose hands the sole manufacture of cutlery and edge-tools is vested for this country, have placed a case filled with the metal in all its stages, in the Polytechnic Institution. There is the fine metallic sand, some beautiful specimens of the cutlery made from it, and the intermediate phases of the iron and steel. An official experiment is expected to be made at some of the government establishments shortly, and it is also intended to forge some chain-cables, anchors, &c., in order to fully set forth the great superiority of the Taranaki iron.

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### *The Patent Type-founding vs. Richard and another.*

From the Lond. Mechanics' Magazine, March, 1861.

This was an action to recover damages upon the ground that the defendants had infringed a patent for an improved manufacture of type.

Mr. Lush, Mr. Hindmarsh, and Mr. Gates appeared for the plaintiffs; and Mr. Knowles, Mr. Grove, and Mr. Webster for the defendants.

It was stated by the plaintiff's counsel, that the patent in question was taken out in 1854 by Mr. Johnson, and this patent was now vested in the plaintiffs. The defendants, Messrs. Miller and Richard, were extensive type-founders in Edinburgh. Before Mr. Johnson's patent, type was made out of a combination of lead and antimony, there being about 75 per cent. of lead. Various attempts had been made to harden type metal, some persons using copper and others zinc; and in the Exhibition of 1851, there was shown a French invention for making type out of copper wire by pressure, without fusion. It turned out, however, that copper would not stand washing, and the invention,

therefore, became useless. Mr. Johnson had been engaged since 1849 in inquiring into the matter, and he was aware that a small proportion of tin had been put into type metal to make it "tougher," but nobody had used it to "harden" the metal. It could not be accounted for chemically that a larger proportion of a soft metal should make the compound harder; but Mr. Johnson found that by using a large proportion of tin he could make a metal that would fuse readily, cool quickly, and come out so hard that you could use the metal as a punch when applied to the ordinary type metal. Mr. Johnson accordingly took out a patent, in which he said that he claimed every combination of the three metals which contained 25 per cent. of antimony and 75 per cent. of tin and lead, of which the minimum of tin must be 25. The defendants, in their circular issued in January, 1856, stated that they had during the last ten months been augmenting the strength of their metal, and this enabled them with confidence to offer a quality of type surpassing every other; and they sold type to the *Times* and other establishments. This type, the plaintiffs contended, had been made in violation of their patent rights, the type having in it more than 25 per cent. of tin.

The defence was, that it had been long known that tin possessed the quality of hardening the metal, and it had been used in combination for making ship nails, which were so hard that they would penetrate oak without being blunted. In Savage's "Dictionary of the Art of Printing," published before the patent, there was a description of tin, lead, and antimony being used for type metal, very much in the proportions given in Mr. Johnson's patent; and in a treatise on "English Founding and Foundries," published in 1778, a mixture of tin and lead was described as being less flexible and more solid and durable than lead. The "French Encyclopædia" also said that a great quantity of tin was used in combination with lead and antimony. Beyond this, the defendants had for many years used tin; and the principle of the use of tin, as provided for by Mr. Johnson's specification, was not new, and therefore his patent was not a valid one.

A great deal of evidence on both sides was laid before the jury, and in the course of the evidence for the defendants the jury stopped the case, and a non-suit was entered.

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## *On Rifled Cannon.* By Capt. Blakeley.

From the Lond. Athenæum. July, 1860.

The writer pointed out that to make an efficient rifled gun, no more was needed than to copy any good small rifle in the number and shape of the grooves, degree of twist, and other details, provided one difficulty was overcome, viz: that of making the barrel strong enough. Taking Sir W. Armstrong's 80-pounder as a standard, Capt. Blakeley gave several examples of large rifled cannon on the model of successful small ones, which had given satisfactory results in every way, except that they had failed after a short time for want of strength. Mr. J. Lawrence, in 1855, rifled a $6\frac{1}{2}$-inch gun with three shallow broad

grooves, like an Enfield, and fired a lead and zinc bullet, like the Enfield. At an elevation of 5°, the range was 2600 yards—150 more than Sir W. Armstrong's; but the gun burst after about 50 rounds. Mr. Whitworth, after making some excellent small arms and nine-pounders, tried a large gun with 4 inches bore, and sides 9 inches thick; but it burst. He then tried another, 11 inches thick, and it, too, burst. He had, however, since made a stronger cannon, whose success was absolute proof that the one thing wanting in the other was strength. Capt. Blakeley explained his own method of obtaining strength, which consists simply of building up the gun in concentric tubes, each compressing that within it. By this means the strain is diffused throughout the whole thickness of the metal, and the inside is not unduly strained, as in a hollow cylinder made in one piece. As the whole efficacy of the system depended entirely on the careful adjustment of the size of the layers, Capt. Blakeley said he was not astonished that Sir W. Armstrong had lately failed utterly in his attempts to carry it out, because he did not put on the outer layers and rings with any calculated degree of tension; "they were simply applied with a sufficient difference of diameter to secure effectual shrinkage," to quote his own words at the Institution of Civil Engineers. To show that the late failure by Sir W. Armstrong did not disprove his, Capt. Blakeley's, theory, he quoted official reports of a trial of a nine-pounder made by himself in 1855, which showed an endurance sevenfold that of an iron service gun, and threefold that of a brass gun, as well as of an 8-inch gun, from which bolts weighing 4 cwt. had been fired, and of a 10-inch gun, which had discharged bolts weighing 526 lbs. Mr. Whitworth's last new 80-pounder was another instance of the successful application of Capt. Blakeley's principle. To quote Mr. Whitworth's own words,—"It was made of homogeneous iron. Upon a tube having an external taper of about one inch, a series of hoops, each about 20 inches long, were forced by hydraulic pressure. Experiments had enabled him to determine accurately what amount of pressure each hoop would bear. All the hoops were put on with the greatest amount of pressure they would withstand without being injured. A second series was forced over those first fixed." This gun was so made at Capt. Blakeley's suggestion. The method of rifling adopted by Capt. Blakeley cannot be made intelligible without a diagram; but it may be described as a series of grooves of very shallow depth, so arranged as to exert a maximum force in the direction of the rotation of the bullet with a minimum force in a radial or bursting direction. Capt. Blakeley exhibited in the court of the building in which the Section met, a 56-pounder constructed on his own plans, from which he had thrown shells on Mr. Bashley Britton's system to a distance of 2760 yards, with only 5° of elevation, which was stated to be a range 200 yards greater than that of Sir W. Armstrong's 80-pounder.

Dr. Scoffern said, he thought Capt. Blakeley had proved his point, that strength was the important desideratum. He said that a large number of Sir W. Armstrong's large guns had lately burst.

Mr. E. Cowper agreed with Capt. Blakeley. Sir W. Armstrong's guns that were said to have burst, were simply cast iron guns hooped. For small arms, he was of opinion that the Lancaster rifle was very successful. The bullet was of lead, and did not jam, as was sometimes the case with the iron shot in the larger guns. If Capt. Blakeley's plan were adopted, he thought that for £10 any gun in the service might be made sufficiently strong.

Mr. Dennis thought that Capt. Blakeley's method of giving strength was right.—*Proc. Brit. Assoc. for Advance. of Sci.*

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## *Firing Gunpowder by Electricity.*

From the London Athenæum, March, 1861.

An important Report has been presented to the Secretary of State for War on the results of elaborate investigations and experiments made at Woolwich and Chatham by a committee on the application of electricity from different sources to the explosion of gunpowder. The report is drawn up by Professor Wheatstone and Mr. Abel, Chemist to the War Department. The following are the conclusions arrived at:—

1st. The explosion of a single charge of powder by means of the phosphide of copper fuse and a magneto-electric apparatus (even of the smallest size generally manufactured) is absolutely certain.

2d. The phosphide of copper fuse is as safe and permanent as any arrangement employed in the service for the ignition of gunpowder by the aid of friction or percussion.

3d. With the employment of a magneto-electric apparatus similar to that used in the Chatham experiments, and termed by Mr. Wheatstone, the "Magnetic Exploder," the ignition at one time of fuses, varying in number from 2 to 25, is certain, provided these fuses are arranged in the branches of a divided circuit in the manner described. To attain this result it is only necessary to employ a single wire, insulated by a coating of gutta-percha or india-rubber, and simple metallic connexions of the apparatus and the charge with the earth.

4th. The explosion of from 12 to 25 charges may be effected in the above manner, at a distance of at least 600 yards from the apparatus, with a rapidity which in its results will in all probability have the practical effect of a simultaneous discharge. This statement, however, only refers to charges on land.

5th. The number of submarine charges which can be exploded with certainty at one time by means of the magnetic exploder is more limited; but if such charges are entirely or partially imbedded in sand, mud, or other dense materials, from two to ten may be fired with certainty. If the charges are suspended in, or are immediately in contact with water, only four can be exploded at one time with certainty. By the employment of separate wires leading from the instrument to each charge, there is little doubt, however, that the results obtained with the magnetic exploder in submarine operations would be quite equal to those definitely established for the ignition of charges on land.

6th. The only important precautions to which it is necessary to attend rigidly, in order to insure uniform success in the application of the magnet, are the proper insulation, throughout, of the main wire and branch wires leading from the instrument to the charges, and the thorough protection of all connexions of wires from the access of moisture.

7th. The system of firing charges by magneto-electricity thus possesses important advantages over the application of the voltaic battery to this purpose: the principal of which are, the small dimensions, weight, and cost of the magnetic exploder; that used in the experiments alluded to in the report weighed only 32 lbs. 11 oz., and all the arrangements in connexion with the instrument are so simple that any injury which they may sustain can be repaired by ordinary workmen.

The Report, we may add, is of great value to civil as well as to military engineers.

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## *Submarine Telegraphic Cable.*

From the London Chemical News, No. 57.

Dr. Fairbairn brought before the meeting four specimens of Submarine Telegraphic Cable, as constructed by Messrs. Hall and Wells. This cable has a copper wire insulated by india-rubber in the centre for the transmission of the electric current. Outside of this are twenty longitudinul strands of hemp steeped in pitch and cork-dust and eight steel wires braided together with twenty-four strands of hemp saturated with Stockholm tar. The specific gravity of the cable in sea-water is 1·4 and its weight in air 0·82 ton per mile. The length that would break with its own weight when suspended in sea water is 10,810 fathoms; its tensile strength being 2·875 tons. Dr. Fairbairn presented an account of experiments which had been made on the elongation of a sample of the cable twenty feet long by the application of different tensile forces. With a force of 4480 lbs. there was an elongation of half-an-inch, and after the weight had been removed the cable was found to be permanently stretched $\frac{3}{16}$ths of an inch. With a force of 6440 lbs. the cable broke after having stretched $1\frac{1}{16}$ inches.—*Proc. Manch. Lit. & Phil. Society, Dec.*, 1860.

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## *Wood's Fusible Metal.*

From the Lond. Chemical News, No. 68.

Lipowitz has made some experiments on the cadmium-alloy, described by Dr. Wood (see *Chemical News*, vol. ii., p. 257). He found that an alloy composed of 8 parts lead, 15 parts bismuth, 4 parts tin, and 3 parts cadmium, possessed the following properties:—It is permanently silver-white, and has a brilliant metallic lustre; it is not so brittle or hard but that it may be obtained in thin leaves or flexible plates; it has a fine-grained fracture, and may be filed without stopping up the file. In dry air it keeps its polish. It expands in cool-

ing, but not so much as bismuth or antimony. Its specific gravity is from 9·4 to 9·41. It softens between 131° and 140° Fahr., and near 140° becomes perfectly fluid. No change in the condition of the metallic mass was observed on remelting after rapidly cooling the alloy. The above properties show that the alloy may be applied to some useful purposes. It may supersede all the quicksilver alloys for stopping teeth: it may be used as a solder whenever the metals soldered are not likely to be exposed to heat. Tin, lead, and Britannia-metal may be soldered together under water above 160° Fahr. Zinc, iron, copper, and brass may also be soldered with the greatest ease under water to which a little hydrochloric acid has been previously added. The alloy is so easily fusible that it may be melted on a piece of paper over a spirit lamp. In the preparation of the alloy, the author recommends the use of the purest bismuth.—*Dingler's Polytech. Journ.*, Bd. clviii. s. 271 and 376.

## AMERICAN PATENTS.

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| Bonnets, . | Lyon & Doubleday, . | Brooklyn, | N. Y. | 19 |
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| ———,—Trim. Heels of | C. H Helms, . | Poughkeepsie, | N. Y. | 12 |
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| Butter-worker, . | P. G. Woodard, | Waterford, | Penna. | 19 |

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| —— Shellers, . | Mathew Tr mble, . | Princeton, | Ill. | 26 |
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| ———— . | C. W. S. Heaton, . | Salem, | Ill. | 12 |
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| ———— . | J. B. Turner, . | Jacksonville, | Ill. | 12 |
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| Drawers,—Substitute for . | S. B. Shultz, . | Princeton, | Ill. | 5 |
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| Egg Beater, . | Walter Hart, . | Philadelphia, | Penna. | 12 |
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| Farinaceous Substances,—Desic. | Huckins & Walker, . | Roxbury, | Mass. | 19 |
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| Fences,—Field . | I. G. Inskeep, . | W. Middleburg, | Ohio, | 12 |
| ————,—Portable | G. B. Mallette, . | Millport, | N. Y. | 15 |
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| —— in Barrels, &c.,—Pressing | E. S. Holmes, . | Wilson, | N. Y. | 12 |
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| Hair Brush, . | J. F. McClure, . | Boston, | Mass. | 19 |
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| ———,—Cutting Apparatus | D. H. Thayer, . | Lansing, | " | 26 |
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| ———,—Fingers for . | E. P. Russell, . | Manlius, | N. Y. | 19 |
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| Hemp Brakes, . | Austin & Creasy, | Carrollton, | Mo. | 5 |
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| Mopholder, . | Wm. R. Axe, . | Beloit, | Wis. | 5 |
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| ———,—Transmitting | Mathaus Kæfer, . | Factoryville, | N. Y. | 5 |
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| Printing Presses, . | A. S. Adams, . | Chelsea, | Mass. | 19 |
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| ——— & Shearing Machines, | P. C. Perkins, . | " | " | 12 |
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| ——— Chairs, . | Archibald McGuffie, . | Rochester, | N. Y. | 26 |
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| Rope,—Making . | F. J. Miller, . | Buford, | Ga. | 5 |
| Saccharine Juices,—Evaporating | Coe & Geon, . | Dalton, | Ohio, | 5 |
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| Salt,—Drying . | G. C. Robinson, | Boston, | Mass. | 26 |
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| ——— . | Lathrop & Justice, | Philadelphia, | Penna. | 5 |
| ——— . | John Moulson, . | " | " | 5 |
| ——— . | C. B. Richards, . | Brooklyn, | N. Y. | 5 |
| ——— . | I. M. Rose, . | City of | " | 5 |
| ——— . | N. G. Ross, . | Cincinnati, | Ohio, | 26 |
| ———,—Hemmers for | Clark Marsh, . | Bridgeport, | Conn. | 5 |
| Shear and Punch, . | T. F. Taft, . | Worcester, | Mass. | 26 |
| Shirred Goods,—Making Elastic | Richard Solis, . | N. Brunswick, | N. J. | 19 |
| Shoes,—Fastening for Gaiter | " . | " | " | 19 |
| ———,—India Rubber . | Christopher Meyer, . | " | " | 19 |
| Skates, . | Hiram Clark, . | Rochester, | N. Y. | 19 |
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| Soaps,—Silicated . | G. E. Vanderburgh, | City of | N. Y. | 5 |
| Spinning Machines, . | Higgins & Whitworth, | Salford, | Engl'd, | 26 |
| Springs,—Arrang. of Carriage | Thomas Phillips, | Ann Arbor, | Mich. | 26 |
| ———,—Cushion . | J. W. Evans, . | City of | N. Y. | 26 |
| ———,—Railroad Car | " . | " | " | 26 |
| Stave Machines, . | Minard Snell, . | Medina, | " | 26 |
| Steam Boilers, . | Leon Pierre Barre, | Paris, | France, | 26 |
| ——— . | John Dunham, . | Detroit, | Mich. | 19 |

| | | | | |
|---|---|---|---|---|
| Steam Boilers, . | John Porter, . | Jefferson, | Texas, | 5 |
| ——— Boiler Furnaces, . | J. R. Robinson, : | Boston, | Mass. | 5 |
| ——— Boilers,—Indic. Water in | H. F. Hart, . | Brooklyn, | N. Y. | 26 |
| ————,—Multitubular | T. J. R. Robinson, . | Boston, | Mass. | 19 |
| ————,—Water Gauges | Hermann Shlarbaum, | City of | N. Y. | 5 |
| ———, or cooling water,—Cond. | W. A. Lightall, . | " | " | 5 |
| ——— Engines,—Condenser for | J. S. Hooton, . | New Carlisle, | Ind. | 5 |
| —————,—Packing for | Jesse Young, . | Franklin Furn. | Ohio, | 26 |
| ——— Trap, . | P. D. Wesson, . | Providence, | R. I. | 26 |
| ——— Valve, . | J. H. Scott, . | Millport, | N. Y. | 5 |
| Steering Navigable Vessls, | Ross and Thos. Winans, | Baltimore, | Md. | 26 |
| Stilts, . | G. N. Cummings, . | Meriden, | Conn. | 26 |
| Stoves, . | S. T. Harvey, . | Baltimore, | Md. | 19 |
| ——— . | M. B. Stafford, . | City of | N. Y. | 19 |
| Stove-pipe Connexion, | J. H. Bell, . | Chelsea, | Mass. | 1 |
| Straw Cutters, . | Stuart & Stewart, . | Fayette co., | Tenn. | 5 |
| ———— . | G. N. and John Relyea, | Veteran, | N. Y. | 19 |
| Stuffing Boxes, . | Ross and Thos. Winans, | Baltimore, | Md. | 26 |
| Stump Extractor, &c., | J. B. Lyons, . | " | " | 26 |
| Sugar Mills, . | Martin Roe, . | Townsend, | Ohio, | 26 |
| —— Solutions,—Evaporating | W. B. Goodrich, | Ashley, | " | 12 |
| Sweeping Streets, . | W. H. Hope, . | Washington, | D. C. | 19 |
| Swimming Propellers, | Jacob Kleiber, . | Memphis, | Tenn. | 5 |
| Syringes,—Enema . | F. B. Richards, . | Boston, | Mass. | 5 |
| ————— | E. G. Stevens, . | Biddeford, | Me. | 5 |
| Table, . | P. P. Warriner, . | Holland Patent | N. Y. | 12 |
| Tanning, . | A. R. Wyeth, . | W. Middletown | Penna. | 5 |
| Tatting Frames, . | D. F. Randall, . | Hartford, | Conn. | 5 |
| Tea Kettles, . | Ransom & Granger, | Albany, | N. Y. | 19 |
| Telegraph Connectors,—Joint'g | J. N. Power, . | City of | " | 5 |
| Threshing Machines,—Fan Att. | Rentgen & Humes, | Keokuk, | Iowa, | 26 |
| ——————,—Carrier | Godfried Weiland, . | Buffalo, | N. Y. | 26 |
| ——————,—Gearing | Lewis Miller, . | Canton, | Ohio, | 19 |
| Time Tell Table, . | Edward Roberts, . | Philadelphia, | Penna. | 26 |
| Traces to Whiffletrees,—Attach. | Luther Humiston, | New Haven, | Conn. | 19 |
| Traps,—Animal . | Deming & Walker, . | Delmar, | Penna. | 5 |
| Trees, Wires, &c.,—Prev. Decay | Benjamin Best, . | Dayton, | Ohio, | 5 |
| Trucks,—Hand . | Wm. C. Reutgen, . | Keokuk, | Iowa, | 19 |
| Turning Irregular Forms, | Jonathan Creager, | Cincinnati, | Ohio, | 12 |
| Type Galleys,—Locking . | S. W. Brown, . | Syracuse, | N. Y. | 12 |
| Valve, . | Cope & Hodgson, | Cincinnati, | Ohio, | 19 |
| Valves, . | Thomas Evans, . | Watkins, | N. Y. | 26 |
| Vehicles,—Regulating Speed of | John Griffin, . | Louisville, | Ky. | 5 |
| Ventilators for Windows, | Loudon & Iversen, . | City of | N. Y. | 12 |
| Vessels,—Spring Tackle for | Wm. Woodbury, | Gloucester, | Mass. | 19 |
| Washing Machine, . | C. E. Toop, . | City of | N. Y. | 5 |
| Watches,—Second hand in stop | Arthur Wadsworth, | " | " | 26 |
| Water Elevators, . | Anderson & Davis, . | Claremont, | N. H. | 26 |
| ———— . | J. M. Perkins, . | Cleveland, | Ohio, | 5 |
| ——— Metres, . | Shailer & Folsom, . | Roxbury, | Mass. | 26 |
| —— Wheels, . | Milton Dilts, . | Columbia City, | Ind. | 26 |
| ———— . | James Reed, . | Newville, | Ohio, | 19 |
| —————,—Scrolls of | W. H. Locke, . | Canton, | Penna. | 26 |
| Windmills, . | A. Giraudat, . | City of | N. Y. | 26 |
| Wind Wheels, . | McPherson & Harbison, | Sacramento, | Cal. | 26 |
| Wrench, . | C. H. Reynolds, . | City of | N. Y. | 26 |
| ———,—Wagon | G. B. Phillips, . | Newark, | N. J. | 12 |

EXTENSIONS.

| | | | | |
|---|---|---|---|---|
| Looms,—Brussel . | E. B. Bigelow, . | Boston, | Mass. | 12 |
| Reaping Machines (4 patents), | Eunice B. Hussey, | Baltimore, | Md. | 5 |
| Steam Chests,—Connect. Pipes | H. R. Dunham, . | City of | N. Y. | 26 |

| | | | | |
|---|---|---|---|---|
| Stone,—Cutting . | Chas. Wilson, . | Springfield, | Mass. | 19 |
| Wire Grating,—Weaving | Henry Jenkins, . | Brooklyn, | N. Y. | 5 |
| ADDITIONAL IMPROVEMENTS. | | | | |
| Lighting Gas,—Electric. Appar. | S. B. H. Vance, . | City of | N. Y. | 12 |
| Thills to Vehicles,—Attaching | Douglas Bly, . | Rochester, | " | 5 |
| RE-ISSUES. | | | | |
| Apples,—Mills for Grinding | W. O. Hickok, . | Harrisburg, | Penna. | 26 |
| Bedstead Fastening, . | E. E. Everitt, . | Philadelphia, | " | 26 |
| Faucets,—Measuring | Ira Kinman, . | Freeport, | Ill. | 5 |
| Fire Arms (4 patents), . | Merrill Pat. Fire Arm Co., | Baltimore, | Md. | 26 |
| Gas Metres, . | C. C. Lloyd, . | Philadelphia, | Penna. | 19 |
| Harrows, . | D. W. Shares, . | Hamden, | Conn. | 12 |
| ———,—Seeding | Henry Hewitt, . | San Francisco, | Cal. | 19 |
| Harvesters, . | Frederich Nishwitz, . | Brooklyn, | N. Y. | 5 |
| ———,—Track Clearers for | W. F. Ketchum, | Buffalo, | " | 26 |
| Photographic Bath, . | Bernard Hufnagel, . | City of | " | 19 |
| Sewing Machines, | Elias Howe, Jr., | Brooklyn, | " | 19 |
| Skirts,—Making Hooped . | Cæsar Neumann, . | City of | " | 19 |
| DESIGNS. | | | | |
| Carpets, . | E. J. Ney, . | Lowell, | Mass. | 19 |
| Clock Case, . | E. C. Brewster, . | Bristol, | Conn. | 19 |
| ——— Front, | Elias Ingraham, | " | " | 19 |
| Stoves, . | A. C. Barstow, . | Providence, | R. I. | 26 |
| ——— . | Horton & Martino, | Philadelphia, | Penna. | 19 |
| Stove, . | Vedder & Ripley, . | Troy, | N. Y. | 5 |
| ——— . | N. S. Vedder, . | " | " | 5 |

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## ERRATA.

In the article entitled Examination of some Questions relative to Transportation, published in the numbers for April, May, and June, pages 217, 289, 368, for "oil," wherever it occurs, read "coal."

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## FRANKLIN INSTITUTE.

*Proceedings of the Stated Monthly Meeting, May* 16, 1861.

John C. Cresson, President, in the chair.

John Agnew, Vice President.
Frederick Fraley, Corresponding Secretary. } Present.
Isaac B. Garrigues, Recording Secretary.

The minutes of the last meeting were read and approved.

Donations to the Library were presented from the Royal Institution, the Royal Astronomical Society, the Statistical Society, and the Chemical Society, London; La Société Industrielle de Mulhouse and la Société d'Encouragement pour l'Industrie Nationale, Paris, France; Thomas Ewbank, Esq., and Jordan S. Mott, Esq., City of New York; and Messrs. Joseph Hutchinson, Frederick Fraley, William A. Rolin, and Andrew Pallis, of Philadelphia.

The Periodicals received in exchange for the Journal of the Institute, were laid on the table.

The Treasurer's statement of the receipts and payments for the month of April was read.

The Board of Managers and Standing Committees reported their minutes.

Candidates for membership in the Institute proposed at the last meeting (6) were duly elected.

Mr. Fraley from the Board of Managers read a preamble and resolutions passed by the Board at their last meeting, proposing an amendment in the Constitution of the Institute, which were discussed and laid on the table until the next meeting.

Prof. Cresson exhibited a lorgnette prepared by Dr. C. M. Cresson for subaqueous exploration, the peculiarity of which consisted in placing a Nicols prism of Iceland spar between the object glass and eye piece, which removed the greater part of the bright light reflected from the surface of water, and thus made objects beneath the water more distinctly visible.

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## METEOROLOGY.

For the Journal of the Franklin Institute.

*The Meteorology of Philadelphia.* By JAMES A. KIRKPATRICK, A.M.

APRIL.—The month of April of this year was unusually warm. The maximum temperature (88°) was noticed on the 24th of the month. The highest point reached previously in April, during the last ten years, was 87° in 1855. The warmest day of the month was the 23d, of which the mean temperature was 73·3°.

The first day of the month was the coldest,—mean temperature 38°; but the minimum (33°) was reached on the 4th. The range of temperature for the month was 55°.

The pressure of the atmosphere was greatest (30·233 ins.) on the morning of the 1st; and least (29·213 ins.) on the morning of the 17th; making the range for the month, 1·020 inches. The mean pressure was greatest, (30·150 ins.,) on the 4th, and least, (29·342 ins.,) on the 17th of the month.

The force of vapor was less at 2 P. M. than usual. At 7 A. M. it was a little below, and at 9 P. M. about as much above the average of those hours for ten years. The relative humidity was less than usual, as will more particularly appear by reference to the following table of comparisons.

Rain fell on nine days to the aggregate depth of 4·150 inches, of which more than one-half fell from the 15th to the 17th of the month. Snow fell for a few minutes, on the morning of the 17th, and is supposed to be the last of the season.

There were but two days on which the sky was entirely clear or free from clouds, and four on which the sky was completely covered with clouds at the hours of observation.

36*

*A Comparison of some of the Meteorological Phenomena of* April, 1861, *with those of April*, 1860, *and of the same month for ten years, at Philadelphia.*

| | April, 1861. | April, 1860. | Apr., 10 years. |
|---|---|---|---|
| Thermometer.—Highest, | 88° | 81° | 88° |
| " Lowest, | 33 | 29 | 20 |
| " Daily oscillation, | 19·05 | 18·90 | 16·79 |
| " Mean daily range, | 5·85 | 7·40 | 6·45 |
| " Means at 7 A. M., | 47·18 | 43·96 | 45·74 |
| " " 2 P. M., | 60·55 | 56·56 | 57·74 |
| " " 9 P. M., | 51·10 | 47·92 | 49·56 |
| " " for the month, | 52·94 | 49·48 | 51·01 |
| Barometer.—Highest, | 30·233 in. | 30·303 in | 30·518 in. |
| " Lowest, | 29·213 | 29·319 | 28·884 |
| " Mean daily range, | ·143 | ·166 | ·176 |
| " Means at 7 A. M., | 29 845 | 29·849 | 29·804 |
| " " 2 P. M., | 29·787 | 29·794 | 29 762 |
| " " 9 P. M., | 29·816 | 29·830 | 29·790 |
| " " for the month, | 29·816 | 29·824 | 29·785 |
| Force of Vapor.—Means at 7 A. M., | ·231 in. | ·210 in. | ·235 in. |
| " " " 2 P. M., | ·226 | ·234 | ·250 |
| " " " 9 P. M., | ·259 | ·230 | ·253 |
| Relative Humidity.—Means at 7 A. M., | 67 per ct. | 70 per ct. | 72 per ct. |
| " " " 2 P. M., | 42 | 50 | 52 |
| " " " 9 P. M., | 65 | 67 | 68 |
| Rain and melted snow, | 4·150 in. | 3·646 in | 4·884 in. |
| No. of days on which rain fell, | 9 | 15 | 13 |
| Prevailing winds, | N 73°30′ W ·177 | N 88°36′ W ·250 | N 70°10′ W ·179 |

*Abstract of Meteorological Observations for March,* 1861; *for the County of Philadelphia, Pennsylvania.*

Philadelphia.—Lat. 39° 57′ 28″ N. Long. 75° 10′ 28″ W.
Height above the sea 50 feet.
Prof. J. A. Kirkpatrick, Observer.

| 1861. M'ch. | Barometer. Mean. | Barometer. Mean daily range | Thermometer. Mean. | Thermometer. Daily oscillation. | Thermometer. Mean daily range. | Force of vapor. 2 P.M. | Relative humidity. 2 P. M. | Rain and snow. | Prevail'g winds. |
|---|---|---|---|---|---|---|---|---|---|
| | Inch. | Inch. | ° | ° | ° | Inch. | Per ct. | Inch. | Direc. |
| 1 | 29 802 | ·263 | 50·7 | 24 | 3·5 | ·418 | 53 | | (var.) |
| 2 | 29·746 | ·085 | 63·0 | 29 | 4·0 | ·479 | 55 | | S W. |
| ☾ 3 | 29·502 | ·245 | 66·0 | 26½ | 3·0 | ·403 | 42 | | S W. |
| 4 | 29·668 | ·192 | 54·7 | 19 | 12·7 | ·109 | 21 | | N W. |
| 5 | 29·903 | ·235 | 35·5 | 19 | 19·2 | ·074 | 30 | | N W. |
| 6 | 29·911 | ·137 | 34·0 | 18 | 5·5 | ·074 | 30 | | W S W |
| 7 | 30·242 | ·331 | 24·8 | 19 | 9·2 | ·118 | 68 | | N W. |
| 8 | 30·251 | ·178 | 35·3 | 25 | 10·5 | ·083 | 29 | | (var.) |
| 9 | 29·565 | ·686 | 45·8 | 17 | 12·5 | ·254 | 80 | 1·245 | (var.) |
| 10 | 29·875 | ·310 | 37 7 | 9 | 8·2 | ·150 | 63 | | W N W |
| ● 11 | 30·120 | ·254 | 33·3 | 13½ | 4·3 | ·087 | 37 | | N W. |
| 12 | 29·941 | ·187 | 46·0 | 23 | 12·7 | ·202 | 48 | | S W. |
| 13 | 29 868 | ·129 | 48 3 | 17 | 5·0 | ·320 | 69 | 0·056 | (var.) |
| 14 | 29·988 | ·120 | 30·3 | 16½ | 18·0 | ·136 | 78 | 0·378 | N E. |
| 15 | 29·753 | ·235 | 33·3 | 9 | 4·3 | ·127 | 60 | | N. |
| 16 | 29 567 | ·188 | 41·3 | 22 | 8·0 | ·090 | 27 | | N W. |
| 17 | 29 881 | ·314 | 40 0 | 24 | 12·0 | ·157 | 52 | | N W. |
| 18 | 30·163 | ·281 | 23·0 | 14½ | 17·0 | ·087 | 55 | | N E. |
| ☽ 19 | 30·067 | ·095 | 24·3 | 13½ | 2·0 | ·070 | 44 | 0·005 | N. |
| 20 | 30 074 | ·035 | 31·8 | 19 | 7·5 | ·108 | 45 | } 0·366 | S W. |
| 21 | 29·692 | ·382 | 32·2 | 6 | 7·7 | ·106 | 58 | | N W. |
| 22 | 29·786 | ·102 | 39 0 | 18 | 8·5 | ·113 | 38 | | N W. |
| 23 | 29·812 | ·140 | 46·0 | 21 | 7·0 | ·128 | 31 | | (var.) |
| 24 | 29·868 | ·207 | 43·5 | 12 | 6·5 | ·133 | 39 | | W N W |
| 25 | 30·096 | ·265 | 43·8 | 20 | 6·0 | ·142 | 35 | | (var.) |
| ○ 26 | 29·868 | ·228 | 57·3 | 22 | 13·5 | ·414 | 72 | 0·106 | S W. |
| 27 | 29·683 | ·213 | 54·3 | 15 | 10·3 | ·390 | 87 | 1·657 | (var.) |
| 28 | 30·026 | ·343 | 47 7 | 16 | 7·3 | ·142 | 35 | | W. |
| 29 | 30·008 | ·098 | 52·2 | 22 | 4·5 | ·190 | 31 | | S. |
| 30 | 29 800 | ·257 | 55·5 | 18 | 5·7 | ·224 | 40 | | W. |
| 31 | 30·213 | ·413 | 43·0 | 16 | 12·5 | ·112 | 31 | | (var.) |
| Means | 29·895 | ·231 | 42·7 | 18 | 8·7 | ·182 | 48 | 3·003 | N 73½° W |

*Abstract of Meteorological Observations for March, 1861; made in Adams, Franklin, and Somerset Counties, Pennsylvania, for the Committee on Meteorology of the Franklin Institute.*

**Gettysburg, Adams Co.** Lat. 39° 49′ N. Long. 77° 18′ W. Ht. 624 ft. Prof. M. Jacobs, Obs.

| 1861. M'ch. | Barom. Mean. | Thermom. Mean. | Thermom. Mean daily range. | Rain and snow. | Prevail'g winds. |
|---|---|---|---|---|---|
| | Inch. | ° | ° | Inch. | Direc. |
| 1 | 29·367 | 66·3 | 13·7 | | W. |
| 2 | 29·2.6 | 63·3 | 5·0 | | W. |
| ☾ 3 | 29·064 | 63·3 | 4·0 | | S W. |
| 4 | 29·240 | 49·0 | 14·3 | | (var.) |
| 5 | 29·500 | 29·0 | 20·0 | | N W. |
| 6 | 29·459 | 33·0 | 10·0 | | W S W |
| 7 | 29·812 | 22·3 | 10·7 | | N W. |
| 8 | 29·727 | 36·3 | 14·0 | | S S W. |
| 9 | 29·131 | 40·7 | 10·3 | 1·100 | N W. |
| 10 | 29·487 | 34·7 | 6·0 | | N W. |
| ● 11 | 29·746 | 29·0 | 5·7 | | N W. |
| 12 | 29·505 | 43·7 | 14·7 | | S W. |
| 13 | 29·417 | 43·3 | 5·7 | | S W. |
| 14 | 29·573 | 31·7 | 12·7 | 0·500 | N E. |
| 15 | 29·373 | 32·0 | 6·0 | | (var.) |
| 16 | 29·147 | 39·3 | 7·3 | | S W. |
| 17 | 29·473 | 37·7 | 11·0 | | N W. |
| 18 | 29·770 | 31·3 | 16·3 | 0·040 | N N E. |
| ☽ 19 | 29·631 | 24·3 | 5·7 | | N W. |
| 20 | 29·599 | 33·0 | 7·7 | 0·020 | S W. |
| 21 | 29·350 | 30·0 | 6·7 | | N W. |
| 22 | 29·472 | 36·7 | 6·7 | | N W. |
| 23 | 29·377 | 44·0 | 9·3 | | S W. |
| 24 | 29·475 | 41·0 | 11·7 | | W. |
| 25 | 29·710 | 41·7 | 8·0 | | (var.) |
| ○ 26 | 29·414 | 56·3 | 14·7 | | S W. |
| 27 | 29·263 | 51·7 | 12·3 | 0·450 | N W. |
| 28 | 29·675 | 45·0 | 5·7 | | (var.) |
| 29 | 29·530 | 51·7 | 6·7 | | S S W. |
| 30 | 29·495 | 49·7 | 11·3 | | N W. |
| 31 | 29·811 | 41·3 | 8·3 | | S W. |
| Means | 29·478 | 41·0 | 9·8 | 2·110 | N 75¼° W |

**Chambersburg, Franklin Co.** Lat. 39° 58′ N. Long. 77° 45′ W. Height 618 ft. Wm. Heyser, Jr., Observer.

| 1861. M'ch. | Barom. Mean. | Thermom. Mean. | Thermom. Mean daily range. | Force of vapor. 2 P. M. | Relative humidity. 2 P. M. | Dew point. 2 P. M. | Rain and snow. | Prevail'g winds. |
|---|---|---|---|---|---|---|---|---|
| | Inch. | ° | ° | Inch. | Per ct | ° | Inch. | Direc. |
| 1 | 29·229 | 64·7 | 12·3 | ·280 | 40 | 38·3 | | W. |
| 2 | 29·155 | 64·7 | 4·7 | ·514 | 54 | 52·3 | | E. |
| ☾ 3 | 28·892 | 64·7 | 4·0 | ·309 | 41 | 43·3 | | W. |
| 4 | 29·116 | 49·0 | 15·7 | ·113 | 29 | 26·3 | | W. |
| 5 | 29·488 | 31·0 | 18·0 | ·103 | 52 | 22·3 | | W. |
| 6 | 29·305 | 34·0 | 6·3 | ·103 | 45 | 24·0 | | W. |
| 7 | 29·629 | 25·0 | 9·0 | ·089 | 56 | 19·7 | | W. |
| 8 | 29·547 | 38·3 | 13·3 | ·108 | 37 | 25·3 | | S W. |
| 9 | 28·980 | 48·7 | 8·7 | ·190 | 74 | 34·0 | 0·953 | W. |
| 10 | 29·336 | 35·0 | 6·7 | ·097 | 39 | 23·7 | | W. |
| ● 11 | 29·583 | 32·0 | 3·0 | ·103 | 45 | 24·0 | | W. |
| 12 | 29·369 | 42·7 | 13·3 | ·204 | 46 | 35·0 | | (var.) |
| 13 | 29·299 | 46·3 | 3·7 | ·219 | 54 | 36·7 | | W. |
| 14 | 29·402 | 32·0 | 14·3 | ·162 | 90 | 29·7 | 0·360 | (var.) |
| 15 | 29·221 | 36·0 | 7·3 | ·113 | 42 | 25·7 | | W. |
| 16 | 29·015 | 46·7 | 8·7 | ·155 | 35 | 30·3 | | W. |
| 17 | 29·334 | 37·3 | 13·3 | ·092 | 34 | 23·3 | | W. |
| 18 | 29·544 | 22·0 | 15·3 | ·089 | 63 | 19·0 | 0·150 | W. |
| ☽ 19 | 29·512 | 26·7 | 4·7 | ·090 | 50 | 20·3 | | W. |
| 20 | 29·360 | 36·7 | 10·0 | ·125 | 40 | 27·3 | 0·100 | (var.) |
| 21 | 29·204 | 33·0 | 9·0 | ·185 | 43 | 20·0 | | W. |
| 22 | 29·316 | 37·3 | 7·7 | ·082 | 26 | 22·7 | | W. |
| 23 | 29·176 | 48·7 | 10·7 | ·118 | 25 | 36·0 | | W. |
| 24 | 29·344 | 41·0 | 7·7 | ·103 | 33 | 29·7 | | W. |
| 25 | 29·497 | 47·0 | 6·0 | ·133 | 32 | 28·3 | | W. |
| ○ 26 | 29·216 | 55·7 | 8·7 | ·340 | 61 | 44·3 | | E. |
| 27 | 29·115 | 52·3 | 11·3 | ·191 | 41 | 33·7 | 0·445 | W. |
| 28 | 29·505 | 48·3 | 4·0 | ·217 | 47 | 36·0 | } 0·210 | W. |
| 29 | 29·358 | 53·3 | 5·0 | ·257 | 43 | 38·7 | | W. |
| 30 | 29·287 | 51·3 | 12·7 | ·160 | 41 | 31·0 | | W. |
| 31 | 29·655 | 42·7 | 8·7 | ·076 | 23 | 22·3 | | W. |
| Means | 29·322 | 42·3 | 9·2 | ·163 | 45 | 29·8 | 2·218 | S 88° W |

**Somerset, Somerset Co.** Lat. 40° N. Long. 79° 3′ W. Height 2195 feet. Geo. Mowry, Observer.

| 1861. M'ch. | Barom. Mean. | Thermom. Mean. | Thermom. Mean daily range. | Force of vapor. 2 P. M. | Relative humidity. 2 P. M. | Dew point. 2 P. M. | Clouds. Sky covered. | Rain and snow. | Prevail'g winds. |
|---|---|---|---|---|---|---|---|---|---|
| | Inch. | ° | ° | Inch. | Per ct. | ° | Per ct. | Inch. | Direc. |
| 1 | 27·684 | 60·3 | 7·0 | ·437 | 68 | 52·0 | 70 | | W. |
| 2 | 27·568 | 62·3 | 3·3 | ·422 | 54 | 48·7 | 47 | | W. |
| ☾ 3 | 27·305 | 61·3 | 1·0 | ·435 | 57 | 50·0 | 83 | 0·097 | W. |
| 4 | 27·472 | 40·3 | 21·0 | ·178 | 55 | 35·0 | 67 | | W. |
| 5 | 27·638 | 20·3 | 16·7 | ·134 | 82 | 26·5 | 83 | 0·139 | W. |
| 6 | 27·602 | 30·3 | 6·7 | ·149 | 70 | 29·0 | 83 | 0·143 | W. |
| 7 | 27·862 | 20·7 | 9·7 | ·121 | 75 | 24·3 | 0 | | N. |
| 8 | 27·705 | 36·7 | 16·0 | ·165 | 49 | 31·7 | 40 | | S E. |
| 9 | 27·352 | 34·3 | 7·7 | ·173 | 72 | 32·0 | 100 | 0·086 | (var.) |
| 10 | 27·664 | 27·0 | 7·3 | ·162 | 84 | 30·5 | 100 | 0·473 | W. |
| ● 11 | 27·884 | 24·0 | 4·9 | ·142 | 69 | 28·0 | 17 | | (var.) |
| 12 | 27·821 | 44·0 | 20·3 | ·233 | 65 | 38·3 | 100 | | W S W |
| 13 | 27·777 | 43·3 | 11·3 | ·228 | 76 | 38·0 | 100 | 0·287 | W N W |
| 14 | 27·839 | 34·0 | 9·3 | ·155 | 58 | 40·3 | 100 | | E. |
| 15 | 27·747 | 29·3 | 4·7 | ·108 | 51 | 24·3 | 43 | | N. |
| 16 | 27·558 | 40·7 | 11·3 | ·232 | 60 | 38·0 | 47 | | W. |
| 17 | 27·822 | 25·0 | 15·7 | ·101 | 59 | 22·8 | 67 | | N W. |
| 18 | 27·936 | 18·0 | 7·0 | ·097 | 73 | 20·3 | 70 | | (var.) |
| ☽ 19 | 27·888 | 22·0 | 8·0 | ·108 | 51 | 24·3 | 7 | | N W. |
| 20 | 27·791 | 28·0 | 8·0 | ·168 | 89 | 30·7 | 67 | 0·357 | (var.) |
| 21 | 27·744 | 23·3 | 4·7 | ·095 | 54 | 21·7 | 67 | 0·086 | W. |
| 22 | 27·869 | 30·0 | 6·7 | ·130 | 58 | 27·5 | 0 | | (var.) |
| 23 | 27·602 | 44·3 | 14·3 | ·228 | 47 | 37·0 | 63 | 0·080 | W. |
| 24 | 27·851 | 35·0 | 12·0 | ·084 | 32 | 22·3 | 47 | | W. |
| 25 | 27·948 | 47·0 | 14·7 | ·268 | 50 | 40·0 | 100 | | (var.) |
| ○ 26 | 27·708 | 58·0 | 11·0 | ·399 | 72 | 50·3 | 100 | 0·094 | S W. |
| 27 | 27·652 | 44·7 | 13·3 | ·253 | 74 | 40·8 | 100 | 0·101 | W. |
| 28 | 27·987 | 41·0 | 6·3 | ·214 | 56 | 38·8 | 53 | | W N W |
| 29 | 27·784 | 54·0 | 13·0 | ·335 | 47 | 43·3 | 73 | 0·151 | S. |
| 30 | 27·873 | 39·3 | 14·7 | ·216 | 91 | 36·7 | 100 | | W. |
| 31 | 28·074 | 38·0 | 8·0 | ·182 | 61 | 33·3 | 50 | | (var.) |
| Means | 27·742 | 37·3 | 10·2 | ·205 | 63 | 34·0 | 66 | 2·094 | S 87¼° W |

*Abstract of Meteorological Observations for March, 1861; made in Dauphin, Northumberland, Centre, and Erie Counties, Pennsylvania, for the Committee on Meteorology of the Franklin Institute.*

| 1861. | Harrisburg, Dauphin Co. Lat. 40° 16′ N. Long. 76° 50′ W. Height, 300 feet. John Heisely, M.D., Observer. | | | | | | | | Shamokin, Northumberland Co. Lat. 40° 45′ N. Long. 76° 30′ W. Ht, 700 ft. P. Friel, Observer. | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M'ch. | Barom. Mean. | Thermom. Mean. | Thermom. Mean daily range. | Force of vapor. 2 P. M. | Relative humidity. 2 P. M. | Rain and snow. | Prevail'g winds. | | Barom. Mean. | Thermom. Mean. | Thermom. Mean daily range. | Force of Vapor. 2 P. M. | Relative humidity. 2 P. M. | Rain and snow. | Prevail'g winds. | |
| | Inch. | ° | ° | Inch. | Per ct. | Inch. | Direc. | | Inch. | ° | ° | Inch. | Per ct. | Inch. | Direc. | |
| 1 | 29·058 | 62·0 | 10·0 | ·440 | 64 | | (var.) | | 29·072 | 64·0 | 15·2 | ·534 | 81 | | W. | |
| 2 | 29·568 | 63·3 | 4·7 | ·493 | 59 | | (var.) | | 29·014 | 62·7 | 9·3 | ·578 | 71 | | (var.) | |
| ☾ 3 | 29·316 | 64·7 | 3·3 | ·531 | 70 | | S W. | | 28·749 | 60·8 | 4·5 | ·636 | 69 | 0·200 | (var.) | |
| 4 | 29·520 | 51·0 | 13·7 | ·253 | 61 | | N W. | | 28·600 | 45·7 | 16·2 | ·248 | 77 | | N W. | |
| 5 | 29·774 | 34·3 | 16·7 | ·164 | 71 | | N W. | | 29·161 | 25·0 | 17·0 | ·143 | 79 | | W. | |
| 6 | 29·725 | 34·7 | 7·0 | ·158 | 64 | | W. | | 29·111 | 30·0 | 6·3 | ·150 | 79 | | N W. | |
| 7 | 30·103 | 27·3 | 7·3 | ·150 | 79 | | N. | | 29·475 | 19·3 | 10·7 | ·084 | 72 | | N W. | |
| 8 | 30·053 | 34·3 | 7·0 | ·180 | 73 | | E. | | 29·481 | 28·7 | 9·3 | ·150 | 80 | | N E. | |
| 9 | 29·396 | 43·3 | 9·7 | ·211 | 82 | 1·120 | (var.) | | 28·640 | 39·7 | 11·0 | ·183 | 90 | 1·700 | N W. | |
| 10 | 29·756 | 38·3 | 5·7 | ·221 | 82 | | N W. | | 29·135 | 36·0 | 5·7 | ·135 | 61 | | N W. | |
| ● 11 | 30·032 | 34·7 | 3·7 | ·172 | 72 | | N W. | | 29·418 | 27·7 | 8·3 | ·155 | 89 | 0·015 | W. | |
| 12 | 29·798 | 42·0 | 7·3 | ·237 | 76 | 0·114 | S W. | | 29·197 | 41·7 | 14·0 | ·296 | 85 | | E. | |
| 13 | | | | ·320 | 86 | | (var.) | | 29·116 | 48·0 | 6·4 | ·347 | 80 | 0·238 | E. | |
| 14 | 29·875 | 31·3 | | ·174 | 100 | 0·430 | N E. | | 29·318 | 27·3 | 20·7 | ·135 | 88 | 0·361 | (var.) | |
| 15 | 29·671 | 35·3 | 5·3 | ·172 | 72 | | (var.) | | 29·127 | 32·8 | 5·5 | ·127 | 60 | | W. | |
| 16 | 29·417 | 45·7 | 10·3 | ·255 | 66 | | (var.) | | 28·825 | 42·5 | 3·0 | ·177 | 63 | | (var.) | |
| 17 | 29·765 | 39·0 | 12·7 | ·162 | 68 | | N. | | 29·150 | 36·2 | 12·7 | ·156 | 71 | | W. | |
| 18 | 30·080 | 23·0 | 16·0 | ·117 | 70 | | N. | | 29·461 | 17·0 | 19·2 | ·079 | 70 | | W. | |
| ☽ 19 | 29·957 | 29·0 | 6·0 | ·175 | 89 | | N. | | 29·375 | 24·5 | 7·5 | ? | ? | | (var.) | |
| 20 | 29·874 | 34·0 | 5·0 | ·198 | 74 | } 0·106 | S E. | | 29·309 | 27·8 | 8·0 | ·100 | 44 | | (var.) | |
| 21 | 29·631 | 34·0 | 4·7 | ·142 | 62 | | N W. | | 29·351 | 29·3 | 10·2 | ·106 | 58 | 0·200 | W. | |
| 22 | 29·741 | 40·3 | 6·3 | ·199 | 62 | | N W. | | 29·146 | 39·0 | 9·7 | ·175 | 66 | | W. | |
| 23 | 29·641 | 45·3 | 5·0 | ·389 | 93 | | (var.) | | 29·077 | 40·3 | 8·0 | ·145 | 39 | | (var.) | |
| 24 | 29·772 | 44·0 | 6·7 | ·196 | 56 | | N W. | | 29·412 | 38·5 | 13·8 | ·193 | 81 | | W. | |
| 25 | 29·976 | 44·7 | 5·3 | ·211 | 60 | | (var.) | | 29·406 | 40·5 | 12·3 | ·126 | 36 | | (var.) | |
| ○ 26 | | | | ·422 | 87 | | S W. | | 29·125 | 54·3 | 14·2 | ·347 | 80 | 0·150 | (var.) | |
| 27 | | | | ·406 | 87 | 0·696 | S W. | | 28·920 | 52·3 | 9·7 | ·422 | 87 | 0·438 | W. | |
| 28 | 29·913 | 47·3 | | ·267 | 66 | | (var.) | | 29·337 | 44·3 | 8·0 | ·220 | 63 | | W. | |
| 29 | | | | | | | N W. | | 29·317 | 52·2 | 7·8 | ·431 | 80 | | (var.) | |
| 30 | 29·696 | 51·0 | | ·452 | 94 | | N W. | | 29·057 | 48·5 | 9·0 | ·294 | 79 | 0·177 | W. | |
| 31 | 30·102 | 44·7 | 9·7 | ·250 | 71 | | (var.) | | 29·488 | 42·7 | 5·8 | ·248 | 77 | | W. | |
| Means | 29·771 | 42·5 | 7·9 | ·259 | 74 | 2·466 | N 64° W | | 29·176 | 39·2 | 10·3 | ·237 | 72 | 3·479 | N 74½° W | |

| 1861. | Fleming, Centre Co. 40° 55′ N. 77° 53′ W. Ht., 780 ft. S. Brugger, Obs. | | | | Erie, Erie Co.—Lat. 42° 8′ N. Long. 80° 12′ W. Height about 640 feet. Benjamin Grant, Observer. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| M'ch. | Thermom. Mean. | Thermom. Mean daily range. | Rain and snow. | Prevail'g winds. | Barom. Mean. | Thermom. Mean. | Thermom. Mean daily range. | Force of Vapor. 2 P. M. | Relative humidity. 2 P. M. | Prevail'g winds. |
| | ° | ° | Inch. | Direc. | Inch. | ° | ° | Inch. | Per ct. | Direc. |
| 1 | 60·0 | 14·0 | | W. | 29·273 | 51·3 | 7·3 | ·279 | 67 | W. |
| 2 | 61·7 | 4·3 | | W. | 29·102 | 65·0 | 13·7 | ·432 | 57 | W. |
| ☾ 3 | 57·3 | 6·3 | 0·050 | W. | 29·588 | 52·7 | 11·7 | ·441 | 82 | W. |
| 4 | 39·0 | 18·3 | | W. | | | | | | |
| 5 | [illegible] | 11·7 | | W. | | | | | | |
| 6 | 29·0 | 3·0 | | N W. | | | | ·161 | 79 | N W. |
| 7 | 19·0 | 10·0 | | W. | 29·653 | 16·3 | | ·096 | 85 | N W. |
| 8 | 37·7 | 18·7 | | S W. | 29·118 | 45·0 | 28·7 | ·145 | 39 | S. |
| 9 | 38·3 | 9·3 | 0·690 | (var.) | 29·046 | 40·0 | 5·7 | ·261 | 84 | W. |
| 10 | 32·0 | 6·3 | | W. | 29·398 | 30·0 | 10·0 | ·150 | 80 | N. |
| ● 11 | 25·7 | 6·3 | | W. | 29·536 | 30·0 | 10·0 | ·111 | 52 | W. |
| 12 | 34·3 | 12·7 | | E. | 29·260 | 36·7 | 8·0 | ·135 | 61 | E. |
| 13 | 43·7 | 12·0 | | W. | 29·311 | 33·7 | 3·0 | ·161 | 79 | N W. |
| 14 | 31·7 | 15·3 | 0·300 | E. | 29·400 | 29·0 | 4·7 | ·161 | 79 | E. |
| 15 | 34·7 | 8·3 | | (var.) | 29·380 | 29·0 | 1·3 | ·126 | 62 | E. |
| 16 | 41·7 | 7·7 | | W. | 29·034 | 41·0 | 12·0 | ·162 | 48 | W. |
| 17 | 31·7 | 12·0 | | W. | 29·555 | 20·7 | 20·0 | ·047 | 42 | N. |
| 18 | 21·3 | 10·3 | | E. | 29·665 | 14·7 | 6·0 | ·051 | 51 | N E. |
| ☽ 19 | 21·7 | 1·7 | | E. | 29·544 | 17·7 | 3·7 | ·047 | 50 | E. |
| 20 | 31·3 | 9·7 | | E. | 29·315 | 32·3 | 14·7 | ·096 | 35 | S. |
| 21 | 27·0 | 6·3 | | W. | 29·291 | 28·7 | 3·7 | ·183 | 90 | N W. |
| 22 | 35·3 | 8·3 | | W. | 29·399 | 30·7 | 2·7 | ·129 | 54 | W. |
| 23 | 42·7 | 8·0 | 0·100 | (var.) | 29·032 | 45·3 | 14·7 | ·159 | 32 | S. |
| 24 | 35·0 | 15·0 | | N W. | 29·352 | 34·7 | 10·7 | ·121 | 53 | W. |
| 25 | 45·0 | 16·7 | | S W. | 29·291 | 38·7 | 14·0 | ·136 | 29 | S. |
| ○ 26 | 51·3 | 6·3 | 0·120 | (var.) | 28·973 | 59·0 | 10·3 | ·342 | 53 | S W. |
| 27 | 46·3 | 13·0 | 0·100 | N W. | 29·080 | 40·0 | 19·0 | ·150 | 63 | W. |
| 28 | 46·3 | 9·3 | | W. | 29·523 | 38·0 | 4·0 | ·123 | 48 | W. |
| 29 | 53·0 | 8·7 | | S W. | 29·060 | 58·3 | 20·3 | ·279 | 58 | S. |
| 30 | 45·3 | 20·3 | | W. | 29·373 | 37·7 | 20·7 | ·172 | 72 | N W. |
| 31 | 38·3 | 10·3 | | (var.) | 29·692 | 35·7 | 2·0 | ·129 | 54 | N E. |
| Means | 38·2 | 10·3 | 1·300 | N 82° W | 29·333 | 37·6 | 10·5 | ·172 | 60 | N 77° W |

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